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RAYTHEON

FINAL REPORT

FOR

ADVANCED ELECTROMETER VACUUM TUBES

(6 May, 1963 - 6 June, 1966)

CONTRACT NO. NAS 5-3311

PREPARED BY:

RAYTHEON COMPANY

465 CENTRE STREET
QUINCY, MASSACHUSETTS 02169

FOR

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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SUMMARY

The object of this report is to detail the work performed from 6 May 1963 - 6 June 1966, under NASA Contract NAS 5-3311.

Designed originally to produce improved versions of production electrometer tubes, this program was later expanded to explore the basic problem areas common to all filamentary electrometer vacuum tubes. Experimental investigations of fundamental types, such as a metal-ceramic structure, a space charge pentode, an inverted triode, and a cathode electrometer tube, were carried out to determine if these constructions offer advantages for low current measurements which are not possible with conventional types. In the evaluation of these and other electrometer tube types, it was necessary to study the areas of tube electrical stability, filament resonance, life performance, effects on tube characteristics of thermal sterilization, and characteristic changes induced by shock and vibration.

Exploratory work led to the development of a radically new control grid identified in the report as an "open frame" control grid, a space charge grid pentode designated QV292, and the development of tube type QV331, an indirectly heated cathode electrometer tube with a grid current of less than 3.0×1.0^{-14} amperes. Also conceived and fabricated for this contract were first samples of tube type QV291, an all new metal-ceramic filamentary electrometer tube. Prototypes of two inverted triodes were fabricated and designated QV293 and QV309 respectively.

Future work should be directed toward completing and improving the metal-ceramic electrometer tube type QV291. Open frame grids should be evaluated for possible use as replacements for the wound grids now used in filamentary and cathode type electrometer tubes. Attention should also be given to the subminiaturization of the present cathode electrometer tube type QV331 and to the reduction of the presently required heater power for this type. A successful reduction of the size and heater power would lead to a version which could be used for space applications and still be capable of withstanding the high thermal sterilization temperatures required in this work.

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1.0 THE PRIMARY PURPOSE OF THE COMPLETE DEVELOPMENT PROGRAM

Initiated as one facet of a comprehensive program sponsored by NASA to evaluate and improve the methods and hardware used to detect minute currents in the range of 10^{-6} to 10^{-18} amperes, this program began as an effort to produce improved versions of existing electrometer tubes being produced at Raytheon. At the same time, through actual experimental work, and a thorough search of the technical literature dealing with electrometer tubes, a major effort was made to recognize and define the problems associated with the manufacture and characteristics of these devices. During the final two years of the contract, the effort was directed to exploring the basic problem areas common to all filamentary electrometer vacuum tubes and to producing samples that had been improved by eliminating or reducing one or more of these known problem areas.

2.0 GENERAL DISCUSSION OF THE TECHNICAL PROBLEM AREAS & METHODS OF ATTACK

2.1 Feasibility Of Producing An Electrometer Tube Having Lower Total Input Power.

When compared with semiconductors, which can be considered for low current measurement use, electrometer tubes have the tremendous advantage of being relatively low noise, high impedance, devices. It became apparent early in the program that a considerable gain would be realized if the total input power of these tubes could be significantly lowered to make them more competitive with the low drain characteristics of semiconductors.

Filament current, which contributes the largest amount to the total input power requirement, has been steadily reduced until tube type CK587, which is in common usage, is rated for .010 amperes at 0.625 volts. Further reductions in filament current can only be realized by increasing the resistance of the filament wire while keeping the filament voltage constant. When one realizes that the above mentioned .010 ampere tungsten filament wire has a diameter of approximately .0002", equivalent to a wire weight of .124 mg/200mm, and that its resistance can only be increased by reducing the cross sectional area, then it can be readily seen that the strength of the wire becomes a limiting factor. Reduction in the active distance between spacers from seven millimeters in tube type CK587 to five millimeters in experimental tube type QV271 necessitated a still further decrease in wire size to counteract the lower resistance of the shorter filament wire.

The filament wire produced for the QV271, with a wire weight of .051 mg/200mm, proved to be the smallest wire that could be manufactured for practical use. A further reduction in the active distance between mica spacers from five millimeters to three millimeters using this same filament, which produced an increase of approximately 50% in filament current, was attained in another experimental test. This test was initiated to study the effects of filament end cooling which ultimately dictates how short a structure can become and still maintain sufficient output.

2.2 Attempts To Develop A More Rugged Electrometer Tube.

The need for a more rugged electrometer tube was evident from the outset as a number of groups began to consider tubes for use in various types of space orientated equipment. The Naval Research Laboratory was particularly interested in an electrometer tube with reduced microphonic output while reports were received from the NASA Technical Officer that a severe problem had developed in the environmental testing of the S-6 (Magnetic Mass Spectrometer) and EOGO subassemblies using conventional electrometer tubes.

The immediate aim of this aspect of the program was to provide a shorter, sturdier tube which would still produce an adequate output for use in electrometer circuits. The disadvantage of lower characteristics associated with a shorter structure is minimized in low current measuring circuits. Therefore, the advantages such as shorter, stiffer, component parts, less grid turns to vibrate, and higher filament resonance can be realized without undue sacrifice. Combining the shorter structure with stronger filament wire and heavier springs raised the filament resonance from approximately 4 kilocycles for the 5886 to approximately 9 kilocycles for the CK587. Still shorter structures, described in this report, show that the filament resonance can be safely raised to at least 13 kilocycles. See block diagram for filament resonance test set in Appendix 3.

In an interesting and informative experiment, performed by the Technical Officer at Goddard Space Flight Center, it was possible to visually observe the movement of tube component parts during sweep frequency vibration. It is only realistic to say that all the parts moved to a greater or lesser degree when the resonant frequency of that particular part was reached. However, several of the principal offenders were identified and have been reduced or eliminated in subsequent tests.

Movement of the whole mount within the glass envelope is probably the largest single contributor to high noise output during mechanical stress. See block diagram of Sweep Frequency Vibration Test Set in Appendix 3. Large output spikes appear at a very low frequency, generally about 500 cycles, during the environmental testing. To prevent this, tubes made in round T-3 bulbs, were secured to the glass by roll crimping the bulbs to the top mica spacer of the tube mount. The same results were obtained with the rectangular Tl 1/2 x 2 bulbs by drawing the glass in against the top spacer using a process developed to protect the filament as much as possible from contamination by oxidation. This process, described in another section, is similar in principle to that employed in an aspirator.

Vibrating grid lateral wires, which cause fluctuations in tube characteristics, can be reduced by using a frame grid with the lateral wires securely anchored to each side of the frame or eliminated entirely by using an open frame grid, which was designed without grid laterals, to perform as a true electrostatic grid.

The effect of the addition of mechanical stops to better anchor loose or moving components must be evaluated on an individual basis, as some additions were effective but others were not.

The effects of increasing or decreasing the mass of the filament connectors were evaluated and proved to be of interest because filaments having greatly reduced connector size exhibited more than one point of resonance. These points occurred at the very low value of 4 - 5 kilocycles.

2.3 Improved Stability In Electrometer Tubes

The need for improved stability in components which make up the sophisticated low current measuring equipment in use today is self evident. Since the electrometer tube is critical to the equipment, more stable characteristics from this important component assume an importance which cannot be overlooked. Perhaps the prime example of the need for better stability centers around modern spacecraft and spaceprobes with their inability to compensate for zero drift beyond a certain limited degree due to restricted weight and space requirements. Whenever this type of equipment drifts beyond the built-in correction range, the reference point is lost and subsequent data becomes meaningless.

Obtaining realistic data when measuring the stability of electrometer tubes is exceedingly difficult because of the inherent instability of other components used in the measuring circuit. To better understand long term drift, a sample of tube type 8520 (a premium CK587) was placed in a test circuit using the best power supplies available and precision low temperature coefficient wire wound plate load resistors. By monitoring the potential appearing on the plate with a differential voltmeter, it was possible to plot changes in characteristics as a function of time. Although not entirely satisfactory, owing to drift in the power supplies, this test was continued for 2000 hours and did supply valuable information.

Another group of 8520 samples were operated under regular life test conditions for 10,000 hours and supplied invaluable information concerning the behavior to be expected from this type during extended operation in regular use.

Probably the best insight into the long term drift characteristics of electrometer tubes was obtained by observing individual tubes operating for prolonged periods of time in a Cary Electrometer Test set, which is equipped with well regulated supplies and special meters. This method is extremely helpful, as a close watch can be kept on the changes occurring in the control grid current as well as the plate and screen current.

The open frame grid, which is dealt with in considerably more detail in subsequent sections, produced favorable effects in both short and long term stability. Employing both CK587 and CK5886 as test vehicles, a series of tests using different aperture sizes were run to evaluate this unique invention. The main contribution of this type of grid to tube stability appears to be the elimination of large control grid current spikes at turn-on (short term), coupled with a lower, more constant grid current level during prolonged operation (long term).

In an effort to identify the optimum operating filament voltage, tubes were placed in operation and the filament voltage was increased and decreased in small increments from the nominal operating point. It was hoped that at some operating point a small incremental change would produce a large percentage increase or decrease in tube characteristics.

At this time there is no evidence to merit a departure from the present operating conditions which have been established through years of experience and work to provide the best activity compatible with long life.

A further experiment was performed to study the short term effect on tube characteristics of raising and lowering the ambient temperature while the tubes were in operation. The arbitrary check points of +100°C and -50°C were used with the result that characteristics seemed to rise slightly at -50°C and fall slightly at +100°C from the starting values experienced at room ambient temperature.

2.4 Shielding For Electrometer Tubes

To avoid excessive fluctuations in grid current, caused by the release of electrons from metal tube parts when acted upon by light or radiation from an outside source, it is necessary to operate conventional glass envelope electrometer tubes inside a light tight container.

In order to eliminate this external container, some form of optical shielding might be built in or deposited on glass envelope electrometer tubes. It was hoped the metal ceramic structure would provide the final solution by providing its own shielding.

Various methods of electrostatic shielding, such as external silver coating of the bulb with an appropriate ground wire or the addition of an internal metal shield with a ground wire were investigated. The methods tried using glass envelope electrometer tubes were either inadequate or introduced additional problems, such as increased physical size, or the generation of spurious noise from movement of the added parts.

Preliminary samples of the metal ceramic structure were also operated in and out of the light tight box to see if this type of structure did provide enough shielding from external light and radiation to eliminate these forms of energy as sources of trouble. The data received indicates considerable promise in this approach.

In order to eliminate the troublesome variations in characteristics experienced when an electrometer tube is operated in a mangetic field, consideration was given to an all non-magnetic tube design. All the parts necessary to produce this version were obtained in non-magnetic materials; such as stainless steel 304 or 305, tungsten, and nichrome V, and samples of these parts were supplied to the Technical Office for evaluation of their magnetic properties.

2.5 Processing Of Electrometer Tubes

Incoming parts which have been fabricated and supplied by vendors, are routed through the Materials Inspection department (M. I. D.) to insure compliance with physical specifications. Metal parts are then ultrasonically washed in stabilized tetrachlorethylene (Philsolv) and hydrogen fired just prior to use.

Mica spacers are hydrogen fired to burn off all possible impurities, and an adherent insulating coating with a slightly rough surface is sprayed on. The sprayed micas are then air baked and hydrolized before use. Ceramic spacers are currently being processed by the manufacturer and are used as received.

Grids, which are fabricated in-house, are cleaned by immersing them in an ultrasonic bath containing "Philsolv". In the final operation, before assembly, the cleaned grids are hydrogen fired.

Metal parts which are to be brazed to metalized ceramics, or are to be heli-arc welded in the final assembly, are ultrasonically cleaned in acetone for ten minutes immediately before use, to eliminate the chance of stray contamination due to handling.

Electrolytic etching is used to clean the surface, and to reduce the tungsten filament wire to the desired size for each particular tube type. A smooth uniform coating of the desired emissive material is then applied to the filament wire by continuous cataphoretic deposition.

In a cathode type electrometer tube, the cathodes are cleaned prior to electropolishing by immersing in "Philsolv" for one minute. The purpose of the electropolishing operation is to improve the emissive properties of the cathode sleeve by removing the surface impurities and oxides,leaving a brightly polished clean surface. The clean cathode sleeves are loaded into racks and a uniform emissive coating is sprayed on by adjusting the number of passes made with the spray gun to provide the specified diameter, coated weight, and coated length.

To make satisfactory welding possible, subminiature button stems, or miniature stems are cleaned to remove copper borate, copper oxide, and excess glass from the stems. The stems are boiled in Raytheon Formula X31-21 for twenty minutes, rinsed in warm water, and boiled for fifteen minutes in sodium hydroxide solution. After rinsing and dipping in isopropanol, the stems are thoroughly dried.

To remove glass particles, lint, and dirt from glass envelopes, they are ultrasonically washed in deionized water and dried.

To eliminate lint, dirt, dust, and contamination, picked up during the assembly process, all finished mounts are washed in deionized water, rinsed in isopropanol and dried. Mount washing is controlled so that only a few hours elapse before the mounts are sealed-in and exhausted.

Dumet leads of the finished tube are cleaned by dipping them in a hot bath of Raytheon Formulation X31-35 and rinsing in warm water. The leads are then successively dipped in Raytheon flux X31-2 and eutectic solder. The tinned leads are cleaned by immersing in hot water and drying in hot air.

Because of the importance of clean grids in successful tube construction, an alternate method of cleaning the grids was tried and compared with the regularly cleaned grids. In this method, the grids were boiled in metalex for two minutes, rinsed in hot water for twenty minutes, dipped in acetone,and hydrogen fired for approximately thirty minutes.

At the inception of the program, it was decided that in order to obtain product uniformity, all mounting would be performed by one (or two if the quantity demanded it) highly trained utility operators working in a clean, air conditioned area. Approximately ninety percent of all the small experimental tests run during the contract were assembled by the same operator over the three year period.

In process storage of parts and finished mounts was originally restricted to special unheated cabinets in the air conditioned area. At a later date, this procedure was changed in an effort to improve the finished product and all finished mounts were stored in heated cabinets outside the air conditioned area. For added cleanliness, finished mounts were stored in desiccators inside the air conditioned area during the final months of the contract.

Several production machines were used to seal-in and exhaust specific tests during the contract. A modified Hoffman rotary machine was used for sealing all of the subminiature flat press filamentary types. Subminiature button types were sealed on a Sylvania rotary, modified to roll crimp the glass envelope to the top mica spacer. The cathode electrometer tube was completely processed on a Sealex machine adapted for this particular type.

Throughout the program a ten port experimental exhaust trolley was used to develop special techniques requiring prolonged or unique processing. This equipment consists of a Kinney Compound rotary backing pump, an oil diffusion pump, and an all metal manifold.

To avoid contamination from back-streaming of the vapor from the oil pumps, NASA supplied Raytheon with a Varian Ion Pumped Ultra High Vacuum System that was designed and built specifically for processing electrometer tubes. The three major requirements that had to be considered in the design of this machine were that it be as free as possible from contaminants; that it be capable of providing an ultra-high vacuum (below 10^{-8} torr); and that it be capable of providing prolonged bake-out of the complete metal ceramic assembly up to temperatures of 600^{o} centigrade. Physically, it consists of two Vac Sorb roughing pumps, a Vacion pump, aTitanium Sublimation pump, a high temperature bake-out oven, and the necessary auxiliary equipment to monitor and control the entire unit when in use. This equipment, while used to a lesser extent for experimental tests on regular glass types, has been used exclusively for the processing of metal ceramic types.

Detailed exhaust, activation, and stabilizing schedules will be included in the Appendix and referenced to the test for which they were used.

2.6 Repeatability Of Tube Characteristics

Wide differences in operating characteristics from sample to sample, or within any given sample, in actuality depend upon the same basic causes.

Parts themselves, although purchased or internally manufactured to the tightest possible tolerances, are different within a given range. Slight variations exist in the processing of the parts which could be magnified by deformation of individual parts during handling. Perhaps the most significant change in the dimensions of a part occur at mounting. One example of this is the slight twist which is sometimes imparted to a grid side rod when it rolls under a welding point. It is well known that even a slight twist tends to pull turns in toward the cathode on one side and force them away from the cathode on the opposite side. The answer to this type of grid deformation is the more rugged box type construction characterized by the frame grid. Results from frame type control grid tests were not as conclusive as had been hoped for, but did serve to point out the importance of the screen grids contribution to the control of electrometer tube characteristics. Open frame screen grids were tried towards the end of the program, but must be redesigned to provide a better plate to screen current ratio before they can be realistically evaluated.

When one considers the diameter of the tungsten filament wire currently being used (approx. .0002"), it is not hard to realize why even the most automated etching and coating machines do not prevent slight differences from taking place along the length of each individual spool. Coupled with these slight differences in the filament itself are the variations caused by the tension and positioning of the filament in the final mount. It is now believed that, regardless of improvements incorporated in the rest of the tube structure, uniformity among tubes will always be limited by the relatively fragile filament and its associated suspension.

Heavier filament springs, nickel filament tabs positioned against the micas, and positioning the filament wire off of the micas were separate experiments designed to improve tube to tube uniformity. Results from these tests indicate that it is possible to shift the average level of characteristics, but indicates also that differences between individual tubes in the same sample still remain.

Still further variations in tube characteristics are caused by the processing cycle. This cycle consists of washing the mounts, sealing them in glass or metal envelopes, and then outgassing the entire assemblies while they are connected to an appropriate vacuum system. The getters are "flashed" (vaporized and allowed to condense on the relatively cool envelope surface) just prior to tip-off to provide the best possible vacuum in the finished tube.

By purposely storing mounts for several months between mount washing and final processing, it was possible to determine that the elapsed time between making a mount and processing it is not as critical as was generally believed.

More difficult to evaluate, but probably far more critical, is the effect of sealing-in on the behavior of the final product. Slight, but continuous changes in the constituents of the gas used for the glass melting fires, the flow of the flushing gas, and the position and intensity of the sealing-in fires themselves, all tend to make this process a variable one in spite of close and constant supervision.

Formation of metal films on tube elements, which change the effective work function of these elements, probably occur during several steps of the processing cycle. This type of action is thought to take place during the cathode breakdown when a high cathode temperature is required to drive off the coating binder and reduce the carbonates in the coating to oxides. Again, while the getter is being flashed, barium metal is undoubtedly deposited in varying amounts throughout the entire mount structure. These deposits, besides varying the contact potential by changing tube element work functions, may also drastically reduce the interelectrode resistance which is very undesirable.

Making use of the so-called "flashless" getters (80% zirconium and 20% aluminum), it was possible to produce tubes with improved grid current levels. This type of getter apparently causes much less contamination of tube insulators than the barium type getters.

The activation of the filament or cathode during aging by means of a "Hot Shot" causes further changes in characteristics, as barium and other metals are vaporized and then deposited once again over the entire tube structure. Failure to obtain a large improvement in this area by eliminating the "Hot Shot" and increasing the time for activation of the cathode, indicates that the effects of a "Hot Shot" are overshadowed by other variables in the finishing cycle. However, activation by burning-in at a very low filamentary cathode voltage has proved to be the only successful way to process some types including the inverted triodes.

Data accumulated on changes in tube characteristics produced by filament cycling is included in the Appendix. This type of change will probably never be eliminated without introducing other undesirable features as the filament apparently repositions itself on the mica continuously as it expands and contracts when turned on and off.

2.7 Changes In Tube Characteristics Induced By Shock & Vibration

To provide comparison levels for evaluation of mechanical improvements to basic tube structures, sweep frequency vibration output tapes were obtained for tube types CK587, CK5886, CK5889, and CK590/QV269. These preliminary results were obtained by sweeping the tubes from 150 - 3500 Hertz @ 15G. Samples of typical tapes for the above types were forwarded to NASA.

Later work led to the development of a tentative proposal for a premium electrometer tube test specification designated type 8520. The sweep frequency vibration test outlined in the proposal and used during the remainder of the contract to measure noise output during mechanical stress is included in the Appendix.

To eliminate the large output spikes at low frequencies, several tests were run with the envelope glass crimped in against the mica spacers. These attempts successfully eliminated the very large spikes, but produced an overall output level which was somewhat higher than control tubes having a firmer bulb to mica bumper point fit. The crimping apparently locks the bulb tightly to the unit and transmits a greater "G" level of vibration to the individual tube elements than is the case when the more flexible mica bumper points are used.

As a direct result of these tests, samples of a special version of the CK587 were supplied to U. S. N. R. L. in early 1965. In addition to having the envelope glass crimped to the top spacers, these CK587 samples had the following special testing performed. They were first read for pentode characteristics per the 8520 specification. The tubes were then vibrated at 8G from 100-2000 Hertz without applied voltages and the pentode characteristics re-read. Only tubes exhibiting less than a 10% shift after vibration from their original pentode values were supplied under this program. Later in the same year additional samples were requested as the Navy had designed this special version of the CK587 into some of its space vehicles. It was emphasized at this time that samples previously delivered had proven far superior to any other electrometer tube evaluated at that location for space flight.

It has already been pointed out that a stronger filament wire (tungsten-rhenium) and heavier filament springs raise the resonant frequency of the filament, thus reducing noise output of the tube. In combination with a shorter tube structure, this type of filament suspension produced a very low noise tube.

Mechanical stops proved very important in reducing the noise output level when they were used to secure an element that was previously dependent only on a force fit in the mica for rigidity. Early in the program a stop was added to the top end of one of the deflectors in the CK587 structure to prevent excessive movement of the mount when vibrated. A similar attempt to make the U-bar filament support more rigid,to prevent the tension on the filament from changing,was not successful. A study of this construction with the NASA sweep frequency vibration test equipment and a strobe light attachment indicated that excessive movement was still taking place. The strobe light setup also gave an indication of the importance of eliminating, or at least keeping all elements that are only fastened at one end, as short as possible.

Actual vibration tests comparing tubes having an open frame type grid with a regular control grid produced approximately the same noise level. In view of the much higher characteristic levels for the open frame grid tubes, this structure appears to be a superior approach.

2.8 Lower Total Grid Current

Portable vacuum tube electrometers for space use are possible only because of the high input impedance of the vacuum tube itself. As a high impedance value depends upon achieving an extremely low residual control grid current, it becomes evident that this characteristic determines the value of any particular tube for use as an electrometer

In order to minimize the effect of leakage between the tube elements on the control grid current, a special Raytheon-formulated alundum spray was applied to the mica insulators. Originally developed for large tubes with rugged components, this spray was adapted for use with the subminiature filamentary tubes being made on this contract. The coarse grain particles which are often accidentally deposited on the inside of the grid holes during mica spraying, effectively decrease the diameter of the holes. The tighter fit which results between the micas and grid legs, necessitates special care during mounting, to avoid damage to the grids. However, the use of the coarse grain spray, by providing the rough type of surface so necessary for good insulating properties, more than offsets the added difficulties of mounting.

Data collected during the contract emphasized the well-known fact that metal deposited on the insulators during evaporation or "flashing" of the getter reduces the effectiveness of the insulators, thus increasing the level of control grid current. The use of a so called "flashless" getter (80% zirconium, 20% aluminum) produced a marked improvement in the grid current level.

Ceramic spacers (99% alumina) in place of the conventional mica insulators were evaluated in the glass envelope version of the metal ceramic tube type QV291. In this application, where no mechanical stress is placed on the spacers, the insulation properties were very good.

Temperature cycling tests performed on the ceramic header and envelope assemblies, designed to house the metal ceramic electrometer tube type QV291, gave evidence of the type of change to be expected in the resistance values across the ceramics from prolonged heating. In this series of tests zero hour resistance readings across the ceramics were obtained and then the ambient temperature was raised to a given value for one hour before being allowed to return to room ambient. At this point the resistance readings were taken again. In successive tests the temperature was raised in increments of 100° centigrade to a maximum value of 500° centigrade. Results obtained indicate that it is quite possible that polarization or stress induced charges in the ceramics will be factors which must be considered in the metal ceramic tubes of the future.

The formation of metal films on tube elements, thus changing their effective work functions, has been discussed in connection with tube characteristic irregularities. It was pointed out that the high filament temperatures produced by large applied potentials during the processing cycle and again while "hot shotting" during the activation cycle, are the two places where this type of action are most likely to occur. In a tube of normal configuration, heat radiation from the filament will cause the emission of electrons from the control grid, which will proceed at a rate controlled by the surface condition of the grid. As the control grid is the element closest to the filament, it is extremely vulnerable to the formation of barium or other metal deposits when the filament is operated at elevated temperatures. These deposits drastically reduce its work function and increase that portion of the total grid current which is made up of electrons emitted from this grid. Little can be done to eliminate the breakdown voltage as a certain minimum voltage is required to drive off the binder completely, but several tests were run eliminating the "hot shot" during activation with good results.

The open frame type of control grid virtually eliminated the high initial grid current peaks and greatly improved the overall level of the grid current. The behavior of tubes using this grid was in fact so revolutionary that a separate section in this report is devoted to the discussion of this invention. All grid current and resistance readings were obtained using the Cary electrometer test set shown schematically in Appendix 3.

2.9 Control Of Grid Current Cross-Over Voltage

Many experiments were devised to control the voltage at which the grid current crosses the zero axis. Using the 1.7-1.8 volts found in the regular CK587 and CK5886 as a reference point, it has been possible to affect a change to approximately 1.6 volts by gold plating the #1 grid. A further reduction to 1.4-1.5 volts was successfully made by platinum plating the #1 grid.

A rather radical change to 1.9-2.0 volts was made by using a new type of control grid. This type of grid, known as an open frame grid, makes use of a face plate with an aperture in it on each side of the grid rods as opposed to the normal wound type of grid. Because of the higher cross-over point experienced with this type of grid, it will undoubtedly be necessary to operate these tubes at a minimum bias of -2.5 volts.

2.10 Gettering

A series of tests were initiated in which tubes without getters, tubes with an added mica shield to protect the tube itself from getter deposits, and tubes containing the "flashless" getters were evaluated. Very little difference in the grid current cross-over point was observed for any of these tests. The true value of the test without getters was probably masked by the higher than usual grid current due to the high level of residual gas.

The 80% zirconium, 20% aluminum getter produced a higher insulation resistance and lower control grid current than the regular barium flash type getter, but like the regular type getter, did not improve the tubes resistance to thermal sterilization.

An attempt was made to produce units in which Cer Alloy 400 paste was applied to the elements to produce a getter, but this method proved unsatisfactory. Later in the program, both strips and pellets of this material were obtained but the evaluation was not completed.

2.11 Trapped Bulb Charges

Experiments were designed to investigate the effect of grounding the internal and external bulb surfaces to prevent the formation of bulb charges. The disturbances caused by the prolonged leaking-off of these charges creates an undesirable drift in tube characteristics.

Several experimental tests had a silver coating applied to the outside of the glass which was grounded to the negative side of the filament while one group was designed with an extra lead that made it possible to ground the outside bulb coating directly. In all cases only slight differences were noted in the performance of these tubes and regular tubes with carefully cleaned bulbs.

For many years glass envelope electrometer tubes have been treated with reactive chloro-silanes which make use of the chemical reaction between the water on the surface of the glass and the silicone to form a highly effective water repellent surface. Discoveries made during the contract indicate that "dry-films" applied in the above manner lead to the trapping of an electrostatic charge of several hundred volts on the water repellent surface layer. This charge, which usually results from touching the glass during the routine handling necessary for testing or use, is sufficient to greatly depress the plate current which is accompanied by a corresponding increase in screen current. Removing the water repellent layer with alcoholic potassium hydroxide reduces the bulb charge to that of a "clean" bulb. However, when bulbs are retreated with a standard chloro-silane application they re-charge as before. These charges may be released by applying several hundred volts to the plate with the filament voltage removed, or by exposing the treated envelope to ultraviolet light of moderate intensity. If not released, the bulb charge may leak off erratically over a long period of time causing noise and a continuous drift in characteristic levels.

The use of an open frame type of control grid has made it possible to produce tubes which do not have the high grid current spikes at turn-on which are usually attributed to such things as glass polarization and trapped electrostatic charges on the envelope. Although the exact workings of this grid are not fully understood, it is very possible that there is a reduction in the internal bulb charge due to the almost - complete enclosing of the filamentary cathode by the grid frame structure.

It is expected that a metal ceramic tube, such as the QV291, might be free of trapped charges since the metal envelope could be easily grounded.

2.12 Piezoelectric Generated Charges

A study of the piezoelectric generated charges in glass was made on several types of glass commonly used at Raytheon. Test samples were produced by beading dumet leads with the appropriate glass under consideration. Charges were generated in all the types of glass used by placing a strain on the glass bead, regardless of whether this was accomplished by improper sealing stress relief, or by the introduction of either mechanical or electrical forces.

This type of generated charge in an electrometer tube can be reduced by keeping the input circuit insulators free of all types of strain. The thermal coefficient of expansion of the leads and the glass must be closely matched and the glass press must be thoroughly annealed for good results. Care must also be taken that an external strain is not placed on the leads and press during use or testing.

Heat cycling tests performed on metal ceramic assemblies indicate that strains produced as the result of high ambient temperatures, or from mechanical constriction of the ceramic headers, leads to the generation of a large piezoelectric potential. Great care must be taken to avoid strains of this type in the production of future metal ceramic electrometer tubes, perhaps by processing at lower temperatures for longer time increments.

2.13 Reduction Of $\frac{1}{F}$ Or Flicker Noise

The true physical nature of flicker noise is not yet fully understood. Until exacting research is carried out to correlate the causes of this type of noise in vacuum tubes, very little can be done to reduce or eliminate the sources. Quiescent "Spot Noise" measurements are used industry wide, as a yard stick to compare noise levels of the different tube types. Flicker noise, which is low frequency noise, is included as one component of the total noise observed at the 10 c. p. s. measuring point.

Test results, measurement procedures, schematics, and a block diagram of the test equipment used are included in the Appendix.

2.14 Control Of Filament Resonant Frequency

Filament resonance, which contributes to the total microphonic output of a tube, cannot be eliminated, but can be controlled by making the appropriate geometric changes. It is desirable for electrometer use to place the resonance as high as possible without causing excessive filament breakage.

Experiments performed with the filament suspended away from the insulators in the comparatively long structured CK5886 (approximately 11.0 MM between spacers) resulted in a low filament resonance of 2.5-3.0 kilocycles.

The combination of a short structure (approximately 5.0 MM between spacers) with a tungsten-rhenium filament wire and heavier than usual filament springs, made it possible to produce a QV271 with a filament resonance of 12.0-14.0 kilocycles. A further reduction in length to approximately 3.0 MM between spacers raised the resonance to 14.0-16.0 kilocycles.

The CK587 family which is readily available from production now has a filament resonance which is between 8.0-10.0 kilocycles.

2.15 Analysis Of Residual Gas In Subminiature Electrometer Tubes

Machlett Laboratories performed an r.f. mass spectrometer analysis of the residual gas in subminiature electrometer tubes to determine if an unknown gas is evolved from the glass during thermal sterilization. (150^{o} centigrade for 150 hours.) This report is summarized in detail in the Appendix.

The following samples were evaluated at Machlett:

Test 1 - T1 1/2x2 bulb (glass type 0120 evacuated on Raytheon System.

Test 2 - Same bulbs pre-evacuated.

Test 3 - T3 bulbs (glass type 8160) evacuated on Raytheon System.

It was determined that water vapor at mass 18 was the major constituent of the gases released from all three tests although it showed a quicker decline than the other major gas component, hydrogen. Test 3 showed very little more gas than the other two tests, but had two and a half times the mass of either; therefore, this type of glass gives off less gas per unit mass.

The analysis failed to turn up a new contaminant, but did confirm the presence of those which are already known.

2.16 Thermal Sterilization

Thermal sterilization, as required for space probe applications, requires that all components undergo relatively long periods of operation or storage at 150° centigrade for 100 hours.

Many experimental samples and production tube types were exposed to the thermal sterilization test and experienced a drastic drop in characteristic level. Results of significant tests will be included under the appropriate test number in the Appendix. A discussion of the tests which appear to have improved resistance to thermal sterilization follow.

It has long been thought that failure of electrometer tubes at high temperatures is caused by release of water vapor and other gases from the glass envelope and mica spacers. In an attempt to reduce this type of poisoning a test was run in which the glass envelopes were baked for 16 hours at 400° centigrade and then rinsed in a 4% potassium hydroxide solution prior to use. Several of the tubes exhibited a poorer level of grid current after sterilization combined with increased characteristic levels. Other tubes had an improved grid current level combined with a drop in other characteristics. The overall change in characteristic level was not as pronounced as in the control.

Still better results were obtained from regular tubes which were processed so as to eliminate the filament "hot shot" at aging. These tubes exhibited improved grid current levels with only minor increases or decreases in other characteristics.

The best results appear to be those obtained with the cathode type electrometer tube QV331. The grid current level of these tubes improves after sterilization with little, if any, change occurring in other characteristics.

3.0 GENERAL DISCUSSION OF EXPERIMENTAL TUBE TYPES DEVELOPED FOR CONTRACT

3.1 8520/CK587

Originally designed merely to reduce the size and filament power drain of the electrometer tube CK5886; the experimental type QV220 was the developmental design which led to the CK587.

After incorporating such improvements as a new mica spray for better insulation between elements and added mechanical stops for improved microphonic performance, the CK587 became the test vehicle for many experiments during this contract.

A further attempt to provide a premium electrometer tube for space vehicles led to the development of a tentative proposal for a very rigid test specification. The CK587 samples capable of passing this test specification are known as tube type 8520.

One of the difficulties encountered early in the program was the lack of sophisticated equipment capable of fully evaluating many of the desired tube parameters in order to accumulate meaningful data. Decisions were made, in close cooperation with the NASA Technical Officer, as to the type of equipment best suited to accomplish the specific tasks outlined. It was then possible to acquire and set up the necessary equipment to fully evaluate tubes.

All data leading to the 8520 specification was filed under test W-63. It is significant to note that premium tubes can be produced to this specification, but at a greatly reduced yield when compared to previous electrometer tube specifications.

3.2 CK590/QV269

This type has the same basic characteristics as the CK587, but is constructed so that the control grid is brought out at the opposite end of the glass envelope from the flat press.

The presence of the grid lead in the tubulation during "tip-off" prevents the use of the standard automatic tip-off mechanism on high-speed production machinery. Samples were processed on a ten port stationary exhaust system and tipped off by hand.

Investigations of this type include tests W-21, 23, 30, and 36.

Advantages of this tube, compared to a CK587, are a slightly lower overall grid current level combined with less decay time - for the initial absorption current to fall to a steady value; and the inherently shorter grid lead which helps prevent the pick-up of external electrical signals.

3.3 QV271

Efforts to produce a tube having basically the same characteristics as tube type CK587, but with a greatly reduced filament power consumption led to the construction of the QV271. The filament is rated for 0.005 amperes at 0.625 volts which reduces the power consumed in the filament circuit by about one half. Associated with this construction is the added difficulty experienced at mounting of handling and assembling the lighter, more fragile, filament. This problem was minimized by using tungsten-rhenium filament wire, which has a much greater tensile strength than plain tungsten. Information for this type is included in test W1 - W3.

Although the production yields would be lower for this type than they are for the tube type CK587, due to increased filament breakage, characteristics can be obtained with the QV271 which are essentially equivalent to the CK587. In addition, the shorter structure of the QV271 provides a higher filament resonance and slightly lower microphonic output.

3.4 QV290

The QV290 is an attempt to redesign the 8520/CK587 from a T1 1/2x2 (.230" x .290" maximum cross section) rectangular bulb to a T3 (.400" diameter) round bulb. It was hoped that this version would retain the desirable characteristics of the 8520 and provide increased resistance to characteristic changes caused by shock and vibration. Physically the T3 bulb is roll crimped to the top mica spacer to prevent movement of the mount inside the glass envelope.

Evaluation of the effects of shock and vibration on tube characteristics has not been successfully completed for this type. At some point in the production cycle the filament becomes contaminated producing unsatisfactory characteristics. Tests W-57, 71, 85, 103, and 107 were attempts to produce good samples.

It is felt that the cause of poor characteristics is something more basic than the crimping operation, as it has not been possible to produce consistently good QV290 tubes even without crimping. The difference may lie in the inverted position of the mount and bulb assembly during sealing-in as well as the increased heat necessary to complete this operation when using the heavier walled T3 glass bulb.

Although glass to mica crimping of the T1 1/2x2 rectangular CK587 structure produced a higher overall level of microphonic output than the control, it might be desirable to further evaluate QV290 samples for this parameter. Thin walled T3 glass envelopes, which would require less heat at sealing-in, could be used in the hope of obtaining improved characteristics. Once an improved level of characteristics were obtained the samples could then be evaluated for microphonic output.

3.5 QV291

One quite unique phase of the contract was devoted to developing a low drain filamentary metal-ceramic electrometer tube. The assembly was to consist of a metal envelope, ceramic stem seal, and internal alumina spacers for the tube element supports. In order to achieve a low level of microphonic noise output, the tube elements were bonded solidly to the top ceramic spacer, which in turn was rigidly bonded to the outside metal envelope. This is not a common practice and allowance for expansion and contraction of the tube elements was accomplished by securing the bottom of the tube elements to the stem pins by means of flexible ribbons.

It was recognized from the beginning that this tube would have to be designed so that the flowing of the copper (normally performed at a minimum of 1150°C.), necessary to bond the tube elements to the top spacer, would have to be performed prior to the insertion of the coated filament. This was accomplished and the final assembly was then heliarc welded together. This type of welding has a very localized heating zone, with the result that excess heat does not penetrate to damage the sensitive filament.

In order to reduce the cooling effect of the ceramics on the filament, both the top and bottom ceramic were reduced, using a Raytheon ultrasonic grinder, in the area where they normally make contact with the filament, to a thickness of several thousandths of an inch.

Another difficult area of investigation was the production of a leak tight subminiature ceramic stem with seven flexible metal leads. The first ceramic evaluated was 99% alumina and repeated efforts at both Coors Porcelain Company and Raytheon failed to produce a leak tight stem. Continued efforts and a change to 96% alumina finally resulted in a limited number of good stems from Coors. These stems made it possible to produce first samples in which all the physical construction problems were overcome (test W-67). Although the characteristic level was low, which at this time appears to be the result of a high gas level, it is felt that an important point in the construction of this tube has been reached.

For better clarification of this important aspect of the contract, a detailed account of the problems and their solutions (or lack thereof) experienced during the development of this type is included in the Appendix.

3.6 QV332

This number has been set aside for a non-magnetic version of the QV291. All the necessary non-magnetic parts were purchased and samples of each were supplied to the Technical Officer for the study of their magnetic properties.

3.7 QV292

A direct reduction in that portion of the grid current, caused by the positive ions that come into existence in the space between the cathode and control grid, has been achieved in the past by making use of a space charge grid tetrode. The QV292 was designed to be such a tube with the addition of a third grid to make it a true pentode. In this type of tube, the grid nearest to the filamentary cathode is operated at a positive potential which effectively keeps the positive ions away from the number two grid which is used as the control element.

Experimental samples were produced in tests W-68, 75, and 90 and evaluated under many conditions. Operated as a tetrode, grid current values of 1 or 2 x 10^{-15} amperes were common. If applications for the use of this tube as a pentode were found, it could be produced or modified as desired.

3.8 QV293

The availability of two German inverted triodes, which were designed specifically for electrometer applications, led to their use as prototypes for samples produced during the contract. The basic design is such that the anode is located between the cathode and the control element.

*Frommhold (see references below) has pointed out that the current of the control electrode in tetrodes has been lowered considerably by the introduction of a space charge grid, due to the isolation of the positive ions from the cathode space. This is equally true in the inverted triode which provides the additional advantage that, for this type of structure, all of the cathode current is being controlled, while in conventional design electrometer tubes with space charge grids, the greater part of the cathode current does not contribute to the amplification, but nevertheless gives off continuous radiation.

After designing and procuring the necessary parts, samples of the QV293, similar to the German DC760, were produced. See tests W-76, 89, and 104.

The characteristics were not equivalent to the German prototype, but it is felt that a minimum amount of future work would be required to obtain the desired results. Tests performed to date indicate that a further slight increase in the diameter of the rectangular control element used, will provide the desired increase in characteristic level.

3.9 QV309

The inverted triode construction of the German tubes results in the low Mu (amplification factor) values of approximately 1.0 for the DC762 and 0.3 for the DC760. The significant difference between the two types is the Mu which is controlled by the spacing between the lateral wires of the wound anode.

*References (Frommhold)

(1) "The Grid Current In Electrometer Tubes"
E. A. Frommhold Nachrichtentechnick 8 (1958), No. 6, Pages 265-268.

(2) "On The Development Of A New Type Of Electrometer Tube"
E. A. Frommhold Nachrichtentechnik, 8 (1958) No. 10 Pages 461-466.

The QV309 is similar to the DC 762 and results obtained for this construction are contained in test W-77. The change in construction which might be anticipated for the QV293 would have to be performed on the QV309 structure also - in order to raise the characteristic level to that of its German prototype.

3.10 QV331

The possible advantages of an indirectly-heated unipotential cathode electrometer tube for laboratory use led to the design and construction of tube type QV331. This type is recommended for equipment where the added stability of the cathode type of construction is desired and heater power consumption is not a significant problem.

The characteristics are similar to those of the 7851, except that the maximum allowable grid current is only 3.0×10^{-14} amperes instead of a typical rating of 1×10^{-12} for the 7851. Unlike the 7851, which has a top cap, the QV331 basing is arranged so that this is a seven-pin single ended miniature tube.

Samples produced in test W-86, 102, 106, and 108 appear to be very satisfactory.

Several potential users are being sampled to see if this type of electrometer tube has characteristics which make it superior to other available types for selected applications.

3.11 QV334

This number identifies the CK587 with an open frame control grid. The physical make-up and function of this grid is fully discussed in the "Significant Development" section.

Tests W-51, 78, 79, and 80 contain information on samples made with different size apertures in the grid face plates. It has been found that this grid improves the overall grid current level, eliminates high grid current peaks at turn-on, and provides a higher characteristic level than are obtained in the same type of tube with a conventional wire wound control grid.

3.12 QV335

This number identifies the CK5886 with an open frame control grid. Data for this type is included in test W-88. It was desirable to evaluate this novel control grid in more than one tube type and the results obtained using the CK5886 as a test vehicle confirmed the findings for this type of grid when used in tube type CK587

4.0 SIGNIFICANT DEVELOPMENTS

4.1 Open Frame Control Grid

A unique grid developed during the contract bears a resemblance to the regular frame type of grid without any wire wound turns, hence the designation, "Open Frame Grid". The basic idea for this grid was originally conceived by Mr. Harold Z. Reed of Goddard Space Flight Center in discussions with Mr. Jack Williams of Raytheon Company. The design and fabrication of the necessary hardware to experimentally verify the basic concept was carried out at Raytheon during the contract.

Physically, this grid is constructed as follows: The two side faces of the grid are fabricated from small sheets of nickel with an aperture punched out of each piece to the desired dimensions. The two faces are then welded onto side rods. The distance between the face plates can be controlled by simply controlling the diameter of the side rods or by forming the faces themselves to provide any desired inside diameter. The size of the aperture is made smaller or larger to regulate the tube characteristics, by providing more or less control of the electrons traveling to the anode. A typical open frame grid is shown in drawing A26077 contained in the Appendix. The basic design, which provides a uniform electrostatic field type of control grid, has many advantages.

Electrically, it reduces the overall grid current level by at least one order of magnitude (from 10^{-15} to 10^{-16} amperes) and provides quick stabilization. It eliminates the high grid current peaks at turn-on which are a characteristic of all other electrometer tubes. It also reduces overall tube noise.

The welded box type construction of this grid is inherently much stronger and more rugged than its wire wound counterpart; it resists deformation due to handling and assembly much better. It does not make use of the regular spiral winding wire so there are no grid laterals to vibrate.

The open frame grid provides a more uniform contact potential over the entire surface of the grid as opposed to a different contact potential for each wire of a regular wound grid.

It minimizes that part of the internal bulb charge which is normally generated by electrons missing the plate and continuing on to the glass envelope. These electrons do not reach the plate since they are deflected in various ballistic paths while passing through the non-uniform electric field produced by the individual turns of a wound grid.

Tube noise is reduced since only uniformly accelerated electrons from the hot portion of the filament travel to the plate; that is, the relatively cold ends of the filament are effectively shielded.

The above explanations do not deal directly with the extremely low level and improved shape of the grid current curve. In an attempt to do this, the literature covering the study of grid current in electrometer tubes was again reviewed, especially the exhaustive studies performed by Frommhold, previously referenced.

In these works it is pointed out that at extremely low grid current levels, after all the known components of grid current are reduced by appropriate means to values less than 10^{-16} amperes, the remaining component of grid current is made up of photo-electrons that is due to continuous radiation. Two methods are set forth as means of decreasing the photo-electric yield. The first is by raising the work function of the control electrode and the second by reducing the effective area of the control electrode that is being struck by continuous radiation.

The substantial shift of the crossover voltage for the open frame grid tubes to the higher value of 1.9-2.0 volts, suggests that the work function of the control electrode has indeed been increased. At the same time it seems reasonable to believe that the removal of the control grid turns from the path of the electron stream has in fact reduced the effective area of the control electrode that is being struck by the radiation.

4.2 Unipotential Cathode Electrometer Tube Type QV331

Experience gained with the subminiature CK587 has shown that it is possible to have a very high insulation resistance between the control grid and the other elements in the tube, even when the distance separating these elements in the glass is quite small. Therefore, it was felt that a single ended miniature cathode type of electrometer tube could be made with a relatively low grid current level, providing the techniques developed in the production of filamentary electrometer tubes were rigidly adhered to.

To provide adequate cathode temperature with a relatively low heater power consumption, the supporting spacers were designed with a square cathode hole. It has been found that the four point contact between cathode and spacers, provided by mounting a round cathode in a square hole, combines the advantages of minimum cathode cooling with a rugged construction. To insure the highest possible insulation resistance between tube elements, the spacers were coated with a coarse grained alundum spray.

The results were very satisfactory, as the finished tubes had stable characteristics and a grid current level below 3.0×10^{-14} amperes. Samples exposed to temperatures of 150° centigrade for 100 hours exhibited little change in characteristics which is very significant; as there is an urgent need for an electrometer tube which can withstand thermal sterilization for future space probes.

4.3 Leak Tight Subminiature Ceramic Stem Assembly

The successful completion of a metal envelope version of a filamentary electrometer tube was dependent, first of all, upon the production of a leak tight seven-pin subminiature ceramic stem assembly. The ceramic insulator, composed of 99% alumina, was designed to be .280" in diameter with seven .0185" holes arranged on a .180" pin circle. This insulator, an external metal sealing ring, and appropriate metal leads, were to be bonded together to form a leak tight stem assembly. Drawing 201572-1, contained in the Appendix, shows the configuration of this assembly.

After a great deal of experimentation with methods and materials, both here and at Coors Porcelain Company, successful assemblies were finally made. For these assemblies the ceramic was changed from 99% to 96% alumina. The metallizing used was lithium-molybdate followed by nickel plating of the ceramic. The metallized and plated ceramic, nickel leads, and nickel sealing ring were then brazed together into a leak tight assembly with pure silver brazing material.

Much is left to be done to fully evaluate the insulation properties of this stem, but in the limited samples to date, it has functioned satisfactorily.

4.4 Fabrication Of A Metal Ceramic Tube Without Filament Contamination

How to assemble a mount and then bond the tube elements and a metal sealing ring to the top ceramic spacer without injury to the filament was a question which went unanswered during the early part of the contract. Finally, the following method was devised to produce the desired results.

The relatively high temperature of 1150° Centigrade required to flow copper, made it mandatory that the bonding operation be performed before the filament was inserted into the mount.

The metal sealing ring to be used at the top of the mount was modified by the addition of a window to allow the entrance of a welding point to make the top filament weld after the sealing ring and unit were bonded together. Drawing 201574 contained in the Appendix shows this assembly technique.

At this point the filament was added and the completed unit was attached to the stem assembly with flexible leads. This is shown in drawing 201569 which is contained in the Appendix.

This assembly was in turn inserted into the long nickel sleeve, which becomes the external metal envelope, and heliarc welded at the top and bottom of the mount assembly to complete the structure without harm to the sensitive filament.

4.5 Crimped Bulb Glass To Top Mica Spacer For Improved Microphonics

Several methods were investigated to crimp the bulb glass to the top mica spacer of tube type CK587. This tube is in a rectangular T 1 1/2 x 2 bulb and therefore does not lend itself to roll crimping from the outside of the envelope. This tube depends on a very short active filament for its emission and any loss of active emitting area, through oxidation, results in a depressed characteristic level.

The following apparatus was devised, whereby an inert flushing gas, such as nitrogen or carbon dioxide, is allowed to flow through a line with a tee arrangement at the end. The tee is oriented so that the gas flowing at the inlet may continue straight through the tee or be diverted to pass out the other outlet. Placing the exhaust tubulation of a vacuum tube over one outlet in the tee, and plugging the other outlet, forces the inert gas into the vacuum tube displacing all the air. Removing the plug from the outlet allows the gas to pass directly through the tee. As it passes the outlet, which has the vacuum tube seated over it, the flow of the gas by the end of the tubulation pulls some of the inert gas out of the vacuum tube and provides a reduced pressure within the tube. If a pinpoint flame is now applied to the glass opposite the mica bumper points, the softened glass will be drawn in against the spacer. The traces of the inert gas which remains inside the tube will prevent oxidation of any of the tube parts.

The above apparatus, which is depicted in an illustration in the Appendix, functioned very well and several hundred successful samples were produced, both for the contract and for others interested in a premium tube for special applications.

Roll crimping, to anchor the bulb glass to the top mica in the round T-3 version of the CK587, can be done quite successfully, on rotary sealing-in equipment. Contamination problems which are believed to be due to other causes, must be resolved before the evaluation of microphonic output for this structure can be completed.

4.6 Production Of A Reduced Size & Filament Drain Electrometer Tube

The detailed evaluation of tube type QV271 in other sections of this report leaves very little more to be said about this reduced size and filament drain electrometer tube. Therefore, only a brief summary of previous discussions is included at this point.

It is possible to produce a shorter tube than the CK587 with comparable characteristics. The effective distance between spacers is approximately seven millimeters in the CK587 and five millimeters in the QV271. The total filament power consumption is reduced by about one half, from 6.25 milliwatts for the CK587 to 3.25 milliwatts for the QV271. Filament resonance, on the other hand, is increased from 8-10 kilocycles for the CK587 to 10-13 kilocycles for the QV271.

It should be borne in mind that there will always be additional manufacturing difficulty in the production of the QV271, due to an increase in filament breakage from the use of the more fragile 5.0 milliampere filament.

5.0 CONCLUSTIONS & RECOMMENDATIONS

5.1 Technical Areas Of Investigation

5.1.1 Analysis Of Residual Gas In Evacuated Glass Envelopes

A study of the residual gas in subminiature electrometer tubes, performed by Machlett, to determine if an unknown contaminant is contributing to the loss of emission during thermal sterilization, disclosed no new information. This item is complete.

5.1.2 Reduction of I/F Or Flicker Noise

So little is known about the true physical nature of flicker noise it is suggested that this area not be investigated further at this time. Primary emphasis should be placed on improving those areas which are both better known and larger contributors to tube noise.

5.1.3 Filament Resonant Frequency Control

In future work the filament resonant frequency will be designed as high as possible consistent with low filament breakage. Experience gained from using stronger filament wire and heavier filament tensioning springs, combined with shorter mounts will be utilized. Samples should continue to be evaluated for this parameter so that the resonant frequency of the filament can be determined for each new structure and maintained at the highest practical level.

5.1.4 Trapped Charges On Glass Envelopes

Although there may be many sources contributing to trapped charges on tube envelopes, by far the most serious one results from the creation of a highly water repellent surface on the glass by the use of a reactive chloro-silane treatment. In the face of unsuccessful attempts to find a better method of "dri-filming" glass envelopes, it is recommended that a functional metal envelope type be perfected as quickly as possible to take the place of the glass versions now in use. The metal envelope can be readily connected to a suitable potential to eliminate the build-up by electrostatic charges.

5.1.5 Piezoelectric Generated Charges

The existance and character of piezoelectric generated charges in glass electrometer tubes was studied in this contract. Data taken indicated that these charges, when measuring grid current below 10^{-13} amperes, contributed to the shape of the grid current curve and were, in fact one of the major causes of instability during the first forty-eight hours of operation. The only known way to eliminate such charges is to replace the glass envelope. However, the change to a metal ceramic tube, which eliminates the glass envelope, provides other sources of piezoelectric potentials in the ceramic insulators. These charges will have to be considered in any further investigations involving a metal ceramic tube.

5.1.6 Gettering

Data from completed tests emphasized the need for some type of getter in both glass and metal envelope tube types. "Flashless" getters reduced contamination from metal deposits on the insulators during the getter activation step, but failed to improve the resistance of the tubes to thermal sterilization.

Further researching of getter materials and techniques might be necessary in the future, especially in connection with the metal ceramic tube type QV291.

5.1.7 Lower Total Grid Current Value

A reduction in the total grid current was attained through innovations or improvements in several important areas. A decrease in the photo-electric effect of the filament was realized by reducing the overall length of the tube structure. The combination of an improved alundum mica insulating spray and the new short structure made it possible to produce 8520/CK587 samples with a grid current of less than 2.5×10^{-15} amperes.

A lower grid current level was also obtained through improved input electrode insulation resistance in two experimental tests, one of which was processed without a filament "hot-shot" and the other in which the regular barium getter was replaced with a "flashless" zirconium-aluminum getter.

Perhaps the most outstanding improvement in the grid current curve, both in magnitude and shape, was obtained by using an open frame structure for the control grid. It is recommended that this type of grid be further evaluated in future studies.

5.1.8 Control Of Grid Current Crossover Voltage

The crossover voltage is defined as that voltage at which the net result of components of the total grid current is zero. At this point the positive currents exactly compensate the negative currents in the control electrode. Methods of changing this voltage have been the subject of much consideration during this program.

During the contract the crossover voltage was changed from -1.4 volts to -2.0 volts in separate tests. Analysis of these tests seems to indicate that a change of work function for one or more of the tube elements, with a corresponding change in contact potential, shifts the crossover voltage of the grid current curve.

This parameter should continue to be evaluated in future work, as there is still much to be learned before the crossover point can be repeatedly controlled and optimized.

5.1.9 Shielding For Electrometer Tubes

The large fluctuation in grid current observed for glass envelope electrometer tubes, when removed from the standard light-tight test enclosure, indicates that all known forms of shielding that are built in or attached to the glass envelope are inadequate as long as stray light is free to enter through the tip or press. Metal ceramic samples, tested under the same conditions, give an indication by their stable grid current that the problem of light penetration is eliminated when this type of structure is used.

Future work should be directed toward the completion of the metal ceramic and non-magnetic metal ceramic types to prevent interference from light, bulb charge and stray magnetic fields.

5.1.10 Improved Stability In Electrometer Tubes

An insight into tube stability was provided by 10,000 hour, long term life data, which shows a slow but steady decline in tube characteristics, accompanied by a gradually improving level of control grid current.

The most significant improvement in stability came as the result of using an open frame control grid, which eliminated the high grid current peaks at turn-on, and provided a lower overall value of total grid current.

Stabilizing time, which is the time interval required to arrive at a steady value of grid current, was greatly reduced in tubes with the open frame grid compared to tubes having standard wire wound control grids.

5.1.11 Repeatability Of Tube Characteristics

When one considers the many variables which contribute to characteristic differences from sample to sample or within any given sample, it is understandable that these differences still exist despite years of technical effort. There are variations in the parts themselves, deformation of elements during handling and mounting, slight differences in the filament wire and filament coating, discrepancies in tensioning and positioning of the finished filament, and variations in the sealing-in and processing cycle, as well as changing work functions of the tube elements from getter "flashing" or filament "hot shotting".

This entire area should continue to be investigated as new devices are developed to advance the state of the art in electrometer tubes.

5.1.12 Change In Tube Characteristics Induced By Shock & Vibration

It has been determined that crimping the glass envelope to the top mica spacer eliminates the large vibration output spikes caused by a loose bulb to mica fit, but increases the overall noise output slightly. Monitoring pentode characteristics, before and after vibration, supplied data which indicates a reduction in characteristic change due to vibration is possible with this type of structure.

The use of tungsten-rhenium filament wire and heavier filament tensioning springs restricted filament movement, which also reduced the change in characteristics before and after vibration.

It is very desirable to have a stable narrow characteristic spread for each type of electrometer tube; and work should continue toward the realization of this objective on any new designs which are investigated.

5.1.13 Attempts To Develop A More Rugged Electrometer Tube

Methods already discussed to limit the change in tube characteristics, induced by shock and vibration, apply equally well to the task of producing a more rugged electrometer tube. Shorter overall length, crimping of the glass envelope to the top mica spacer, added mechanical stops, and the elimination of grid lateral wire vibration by the use of open frame grids are improvements which contribute to overall performance and rugged construction.

This type of work must continue in any further investigations, in order to have newly-developed tube types meet the standards which have already been attained with electrometer tubes produced to date.

5.1.14 Processing Of Electrometer Tubes

When dealing with the subminiature electrometer tubes of today, it is imperative that the processing cycle be such that the tiny filamentary cathode is protected from contamination (especially oxidation) at all stages of production. Of equal importance is the necessity of protecting the insulators and tube elements from metal film deposits, which lower the resistance and work function respectively of the affected parts.

Data from past tests indicate the need for continued efforts to find better methods and materials for gettering, as well as a better understanding of what takes place during the sealing-in operation. In addition, to determine the true effects of contamination from back-streaming of the vapors from oil pumps, the Varian Ion Pumped Ultra High Vacuum System should be further evaluated.

5.1.15 Thermal Sterilization

With the growing importance of space probes, more urgent demands are being made for components that can withstand high temperatures for prolonged periods of time. (150° centigrade for a minimum of 100 hours.)

Tube type CK587 samples, fabricated with glass envelopes which were baked at 400° centigrade overnight and dipped in a KOH solution prior to assembly, were considerably better after thermal sterilization than the control. Tube type CK587 samples processed without a filament "hot-shot" were also better than the control after both received the same high temperature treatment.

The cathode electrometer tube, type QV331, produced the best performance with improved grid current level and only slight changes in characteristics after being thermally sterilized.

It is recommended that work continue with the cathode electrometer tube (QV331) and the metal ceramic tube (QV291) to further improve their resistance to high temperature sterilization.

5.2 Experimental Tube Types

5.2.1 QV271

The QV271, a shorter, reduced filament drain version of the CK587, can be produced with characteristics which are essentially the same as those of the CK587. However, increased difficulties associated with the handling and mounting of the lighter more fragile filament, substantially decreases the overall yield.

It is recommended that this type be used in place of the 8520/CK587 only if the application is such that the reduction in filament drain from 10 milliamperes to 5 milliamperes is of paramount importance.

5.2.2 8520/CK587

The 8520/CK587 is a premium tube which can be produced in its present form. This type should continue as a basic design which is available for space applications.

5.2.3 CK590/QV269

Designed as a double ended version of the CK587, with the control grid brought out at the opposite end of the envelope from the flat press. This type presents certain difficulties at "tip-off" due to the presence of the lead to the control element in the exhaust tubulation.

However, the long leakage path over the glass, between the control element and the rest of the tube elements, the much shorter length of the control element lead reducing external pick-up, and the type of physical construction which is superior for certain packaging applications, may make it desirable for certain applications.

5.2.4 QV290

The designation QV290 has been given to an experimental tube type which is the result of attempts to redesign the 8520/CK587 into a round T-3 glass envelope. It was hoped that all the desirable features of the 8520 could be retained and in addition, changes in characteristic levels resulting from shock and vibration could be reduced to a minimum.

However, changes in the processing cycle to accommodate the button type of construction and the use of a heavier glass envelope, introduced variables that have prevented a satisfactory level of characteristics from being attained.

Due to the concern that exists that a substantial decrease in broadband microphonic output may not be achieved, coupled with the difficulties of producing satisfactory samples for environmental evaluation, leads to the conclusion that the entire question of continuing the specific design approach taken thus far should be reviewed.

5.2.5 QV291

First samples of this important metal ceramic electrometer tube have been produced in which all the construction problems were overcome. It will now be possible to initiate tests to evaluate and center tube characteristics. Work should continue with the highest priority to produce a satisfactory metal ceramic electrometer tube and to evaluate its performance capability.

5.2.6 QV292

The QV292 is a space charge grid electrometer tube in a T-3 glass envelope with the addition of a third grid to make it a true pentode. Working samples were produced during this program, and no further device development is recommended unless some specific application is found where the pentode design of this tube can be effectively utilized.

5.2.7 QV293

The QV293 is the Raytheon version of the German inverted triode DC-760. The physical construction problems have been solved and working samples were produced which have characteristics lower than the design objectives. It is believed that the geometric changes necessary to center the characteristics at the desired level are known and should be carried out in a future program.

5.2.8 QV309

The QV309 is the Raytheon version of the German inverted triode DC-762. The only difference between the DC-760 and DC-762 is the amplification factor. Therefore, the same changes contemplated for the QV293 in any future program should also be carried out for the QV309.

5.2.9 QV331

The QV331, a unipotential heater cathode electrometer tube, can be produced quite successfully. The ability of this cathode electrometer tube to withstand high thermal sterilization temperatures is a significant reason for continued efforts to improve and adapt this type for space oriented service.

5.2.10 QV334, QV335

The above experimental numbers are reserved for tube types CK587 and CK5886 respectively, to designate versions of these tube types constructed with open frame control elements.

In both types this unique control element is responsible for an improved grid current level and elimination of grid current peaks at turn-on. The foregoing improvements are possible in conjunction with a much higher characteristic level than can be attained with tubes having a wound control element.

Efforts should continue to further study this type of grid in electrometer tubes. In addition, samples should continue to be evaluated to optimize their performance in end-use equipment designs.

6.0 AREAS FOR FUTURE CONSIDERATION

6.1 Metal Ceramic Electrometer Tubes

There is no doubt that the first area for consideration in any further endeavor should be concerned with the completion and improvement of a subminiature filamentary metal ceramic electrometer tube such as the QV291.

First samples of this type have been produced in which the construction problems have been successfully overcome. Characteristic levels need improvement, but it is hoped that this will be remedied by the addition of a suitable getter to reduce the high gas level found in early tubes.

The elimination of bulb charge, the possibility of immunity to high temperature operation and storage, increased resistance between tube elements by the use of 96% or 99% alumina spacers, and the elimination of poisoning during operation from water vapor and gases released by the mica spacers and glass envelope, offer opportunities for significant improvements which cannot be overlooked.

Parts made from non-magnetic materials are available and the substitution of these components for the regular parts used in the QV291, would result in a version that is expected to be impervious to outside magnetic fields. The experimental number reserved for this type is QV332.

6.2 Cathode Type Electrometer Tubes

A second major area that offers substantial opportunities for improvement in the field of vacuum tube electrometers is concerned with the development of a unipotential heater cathode electrometer tube for low drain equipment.

The QV331 is a cathode type electrometer tube which was developed for applications in which an ultra-low heater power input was not needed. A program should now be initiated, with the QV331 as a test vehicle, to build and evaluate samples to determine the lowest drain heater which can readily be used with the present construction and still produce a satisfactory tube.

A further developmental effort could be expended to produce samples with a more exotic heater cathode arrangement, in an effort to lower the heater power consumption to a value more comparable to the high drain filamentary tubes. It might be expected that this low heater power version of a cathode electrometer tube would be essentially unaffected by high temperature sterilization.

6.3 Open Frame Grid Designs

A third area which merits future consideration is that of the open frame grid. Efforts to date primarily have been concerned with the use of this grid as a control element in filamentary tube types. A logical future step appears to be the evaluation of this grid in a cathode electrometer tube. Additional efforts should be directed toward the evaluation of improved open frame configurations to determine if this type of grid construction will produce improved performance when utilized in place of all the conventional wound grids in electrometer tubes.

6.4 Subminiature Cathode Electrometer Tube

An area which could be considered by itself or combined with 6.2 is the reduction in physical size of the present miniature tube type QV331. The physical size could be reduced to that of a T-3 subminiature while maintaining the present characteristics and grid current levels.

APPENDIX I

DATA SHEET, PARTS LIST AND TUBE DRAWING FOR EACH EXPERIMENTAL TYPE DEVELOPED FOR THE CONTRACT

8520/CK587

QV290

QV291

QV292

QV293

QV309

QV331

RAYTHEON

TECHNICAL INFORMATION SERVICE

Technical Information

8520
SUBMINIATURE
ELECTROMETER
PENTODE

Raytheon type 8520 is a subminiature electrometer pentode with very low filament power, good emission stability, and low microphonics, and is outstanding because of its extremely low grid current. It has sufficient voltage gain for operation in the electrometer stage of a multi-stage circuit. The flexible terminal leads may be soldered or welded directly to the terminals of circuit components.

ELECTRICAL DATA

ABSOLUTE MAXIMUM RATINGS

	UNITS	
Filament Voltage (dc)	0.625	±10%
Plate Voltage	45	volts
Screen Grid Voltage	45	volts
Total Cathode Current	100	uAdc

AVERAGE CHARACTERISTICS

Filament Voltage	0.625	volts
Filament Current	10	mA
Plate Voltage	8	volts
Screen Grid Voltage	5.5	volts
Control Grid Voltage	-2.0	volts
Plate Load Resistance	---	ohms
Plate Current	8	uAdc
Screen Grid Current	2.5	uAdc
Amplification Factor (Grid 2 Conn. to Plate)	2.2	----
Transconductance	17	umho
*Voltage Gain	*1.85	----
Maximum Control Grid Current	2.5×10^{-15}	amp

* Gain tested with grid 2 connected to plate; Eb = 22.5 Vdc; Ec1 = -3 Vdc; RL = 200 K ohms

Tentative Data

These data identify a particular development design; the descriptive data are subject to change.

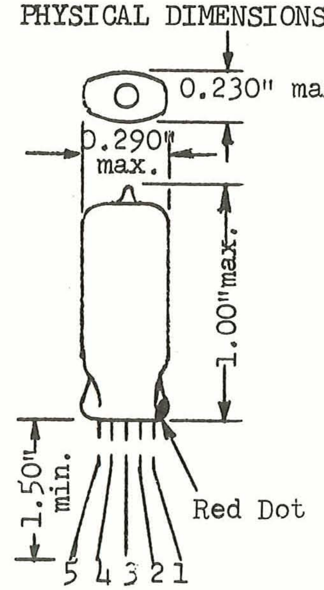
MECHANICAL DATA

Envelope...T1½x2 Glass
Base.......Pinch Press

0.016" tinned flexible leads. Length=1.50"min. Leads on 0.040" center-to-center spacing.

Mounting Position..Any

PHYSICAL DIMENSIONS



TERMINAL CONNECTIONS*:

Lead 1 Plate

Lead 2 Screen grid

Lead 3 Filament positive, one deflector

Lead 4 Filament negative, one deflector

Lead 5 Control Grid

*Lead 1 is adjacent to red dot

Printed in U.S.A.

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR A — CK587(QV220) — SHEET 1 — REVISION 2

DIST.
A
5
15
18.45
23
24
30.60
31.5
38

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND.
1	TUBE ASSEMBLY	1½ x 2 In-Line	20122	(1)		5147
2						
3	BULB ASSEMBLY (Cut)		21531-4	(1)		5114
4	Bulb Assembly (Unfinished)		21591-1	(1)		
5	Tube-Glass (Bulb)	Class .220 x 76.0mm O.L. 0120 Glass	200016-4	1	502-001	
6	Tube-Glass (Exhaust)	Class .140 x 32.0mm O.L. 0120 Glass	5425-67	1	502-001	
7						
8	SOLDER (Lead Tinning)	63%Sn-37% Pb Ingot	201101-632	AsReq	004-001	5078
9						
10	PAINT (Maroon Dot)		-	AsReq		5507
11						
12	PAINT		-	AsReq		5022
13	Tube Marking	Per Tube Marking Index	3633	-		
14	Tube Marking (Date)		3645	-		
15						
16	MOUNT ASSEMBLY		201253	(1)		5103
17						
18	Spacer (Coated-Bottom)		20794-8	(1)		5034-038
19	Coating		-	AsReq		
20	Spacer	Fair Stained Mica	20794-5	1	205-003	5202-065
21						
22	Spacer (Coated-Bottom) Intermediate		20794-8	(1)		5034-038
23	Coating		-	AsReq		
24	Spacer	Fair Stained Mica	20794-5	1	205-003	5202-065
25						
26	Grid Assembly #1		7724-47	(1)		5033-202
27	Wire (Winding)	.001 Dia. H.B.	201102-629	AsReq	001-002	
28	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
29						
30	Grid Assembly #2		5399-64	(1)		5033-202
31	Wire (Winding)	.0016 Dia. H.B.	201102-631	AsReq	001-002	
32	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
33						
34						
35						

DIMENSIONS IN INCHES UNLESS NOTED

REVISIONS

PCC 62-5593
AJ rjs
1-2-63 0

POC 63-5048
Grid #1 (7724-47) was incorrectly specified as 7721-72.
EMW rjs
2-15-63 1

POC 63-5133
O.S.5103 added to Mount Asby.
WEH rjs
3-13-63 2

RAYTHEON COMPANY INDUSTRIAL COMPONENTS DIVISION	PARTS LIST	CONSTR A	CK587 (QV220)	SHEET 2	REVISION 1

DIST.

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18.45
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24
30.60
31.5
38

ITEM	TITLE AND DESCRIPTION	DWG. NO.	QUAN.	M. P.	OPERATION STAND.
36	Spacer-Deflector-Spring Assembly	20929-6	(1)		
37	Spacer (Coated-Top)	20794-8	(1)		5034-038
38	Coating	-	AsReq		
39	Spacer Fair Stained Mica	20794-5	1	205-003	5202-065
40	Spacer (Coated-Top) Intermediate	20794-8	(1)		5034-038
41	Coating	-	AsReq		
42	Spacer Fair Stained Mica	20794-5	1	205-003	5202-065
43	Plate (Deflector) .005 Nickel	9465-1	1	205-002	5053-202
44	Wire-Bent (Support) .020 Dia. Nickel	9496-1	1	205-002	5053-203
45	Spring (Filament) 8.23 - 8.57mg/200mm CLS-218 Tungsten	21119-1	1	001-004	5053
46					
47	Plate (Deflector) .005 Nickel	9465-1	1	205-002	5053-203
48					
49	Plate .005 Nickel	9283-1	2	205-002	5053-203
50					
51	Filament Assembly RCA Converted Machine 15.Jmm Connector	21252-38	(1)		
52	Ribbon (Connector) Sh.3 for ALT. .0015 x .591 x .020 C.L. 80-20 NiCr	201106-699	1	003-002	
53	Filament Wire (Coated) 25.0 mm C.L.	5167-133	(1)		5009
54	Coating	-	AsReq		
55	Filament Wire (Etched) .120 - .128/200mm	205167-133	AsReq		5102
56	Wire-Tungsten .32 - .34mg/200mm	201103-602	AsReq	001-006	
57					
58	Shield (Bottom Filament Support) .005 Nickel	21077-1	1	205-002	5053-203
59					
60	Getter 0.7mg Pellet #828 Alloy-.005 Nickel Flag	9495-1	1	205-002	
61					
62	Wire-Flattened (Plate Lead) .016 Dia. Dumet	22272-3	1	001-016	
63					
64	Wire-Bent & Flattened (G2 Lead) .016 Dia. Dumet	201083-1	1	001-016	
65					
66	Wire-Bent (Bottom Fil. Lead) .016 Dia. Dumet	201085-1	1	001-016	
67					
68					
69					
70					

DIMENSIONS IN INCHES UNLESS NOTED

REVISIONS

RETYPED:
Alternate part relocated to sheet 3.
PCC 64-5194.
Spacer-Deflector Spring Assembly (20929-6) was 20929-4.
Wire (Plate Lead), 22272-3, was Weld (7399-1).
Wire (G2 Lead), 201083-1, was Weld (9826-3).
Wire (Bottom Fil. Lead), 201085-1, was Weld (20833-1).
RJS
8-14-64 1

RAYTHEON COMPANY INDUSTRIAL COMPONENTS DIVISION	PARTS LIST	CONSTR A	CK587(QV220)	SHEET 3	REVISION 2

DIST.
A
15
18.45
23
24
30.60
31.5
38

ITEM	TITLE AND DESCRIPTION	DWG. NO.	QUAN.	M. P.	OPERATION STAND.
71	Wire-Bent & Flattened (Top Fil. Lead) .016 Dia. Dumet	24011-3	1	001-016	
2					
3	Wire-Bent (G1 Lead) .016 Dia. Dumet	24136-1	1	001-016	"
4					
5	Ribbon-Cut (Stop) .005 x .030 x 2.0mm C.L. Nickel	208312-25	2	003-004	5053-204
6					
7					
8					
9					
80	ALTERNATES FOR PREFERRED PARTS:				
1	Ribbon (Connector)	201106-674			
2					
3					
4					
5					
6					
7					
8					
9					
90					
1					
2					
3					
4					
5					
6					
7					
8					
9					
100					
1					
2					
3					
4					
5					

DIMENSIONS IN INCHES UNLESS NOTED

REVISIONS

RETYPED:
Alternate part relocated.
POC 64-5194.
Wire (Top Fil. (Lead), 201087-3, was Weld (8831-1).
RJS
8-14-74 1

POC 64-5252
Ribbon-Cut (Stop) (208312-25)
Quan. req. was 1
PCC 64-5259
It. 71 was 201087-3
RCS
10-1-64 2

3	DIMENSIONS IN INCHES UNLESS NOTED. FOR TERMINAL CONVENTIONS SEE TUBE ASSEMBLY 6794. FOR BILL OF MATERIAL SEE SHEET ONE	RAYTHEON MANUFACTURING COMPANY RADIO RECEIVING TUBE DIVISION NEWTON, MASS.	A20122 SHEET TWO 9
		TUBE ASSEMBLY T1½x2 (SHORT TYPE - 5 LEADS) UNSHIELDED RMC OUTLINE ER2	
	BILL OF MATERIAL		REFERENCE DRAWING

18.45

19

21

28

29²

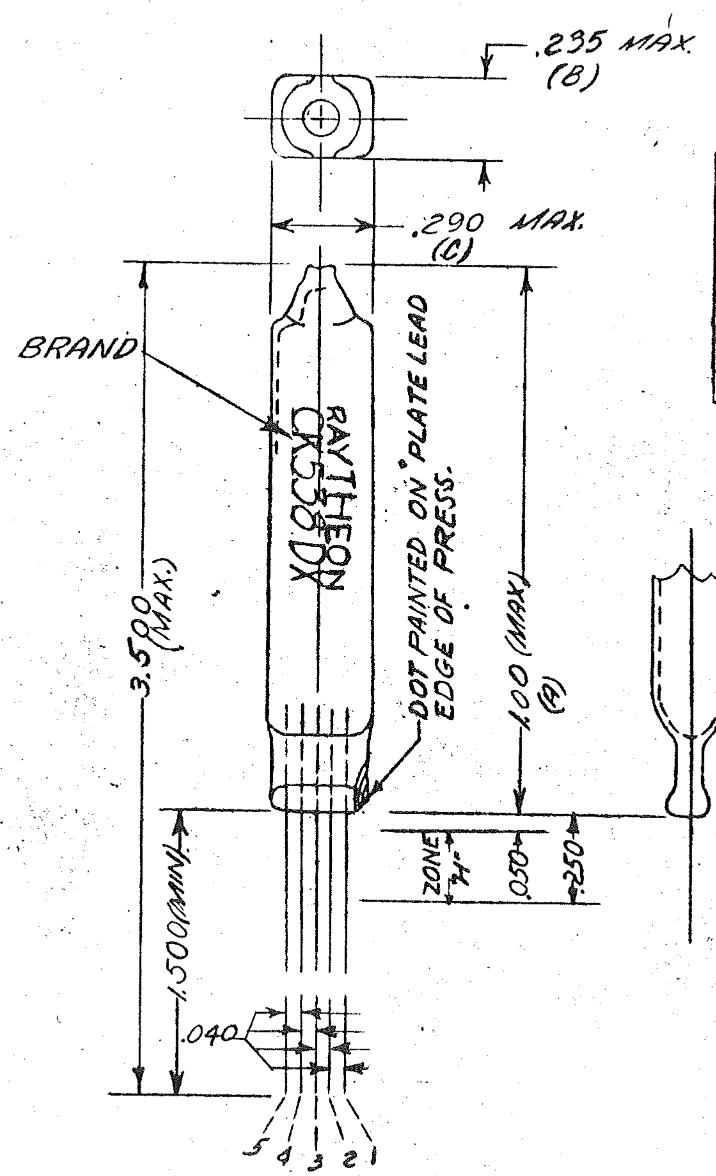
30.60

31.4

33

34

37



TUBES TO BE GAUGED FOR MAXIMUM DIMENSIONS (A), (B) & (C), IN A GAUGE PER DRAWING 8984.

TERMINAL CONNECTIONS					
TUBE TYPE NUMBER	TERMINAL NUMBER				
	5	4	3	2	1
6419	F-	G1	F+	G2	P
CK549DX	F-	G1	F+	G2	P
CK587	G1	F-	F+	G2	P

NOTE:

TUBE MARKING BRAND IN "GOLDEN YELLOW" PAINT TO BE CENTERED APPROXIMATELY ON FACE OF TUBE INDICATED, WITH INDEX DOT AT RIGHT.

DATE CODE IS STAMPED WITH PAINT ON OPPOSITE FACE.

LEAD DIA., AFTER TINNING TO BE .015-.018 IN ZONE "H". DIAMETER TO BE .021 MAX BETWEEN ZONE 'H' AND END OF LEAD.

REVISIONS	
POC 62-5312, TYPE CK538DX OBSOLETED. EMW 12-7-62 rjs	8
POC 62-54305, TYPE CK587 ADDED. AJ 12-17-62 rjs	9

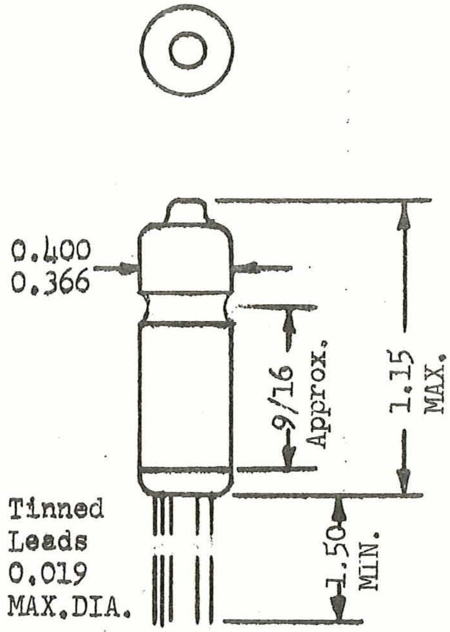
RAYTHEON

SUBMINIATURE ELECTROMETER PENTODE — QV290

Raytheon experimental type QV290 is a subminiature electrometer pentode with very low filament power, good emission stability, low microphonics, and low grid current. This is a version of type 8520 in T3 bulb.

MECHANICAL DATA

Envelope ..... T3 Glass
Base ..... Button E8-10
Mounting Position . Any



ELECTRICAL DATA

ABSOLUTE MAXIMUM RATINGS

	UNITS	
Filament Voltage (dc)	0.625	±10%
Plate Voltage	45	volts
Screen Grid Voltage	45	volts
Total Cathode Current	100	uAdc

TYPICAL CHARACTERISTICS

Filament Voltage	0.625	volts
Filament Current	10	mA
Plate Voltage	8	volts
Screen Grid Voltage	5.5	volts
Control Grid Voltage	-2.0	volts
Plate Load Resistance	---	ohms
Plate Current	8	uAdc
Screen Grid Current	2.5	uAdc
Amplification Factor (Grid 2 Conn. to Plate)	2.2	----
Transconductance	17	umho
*Voltage Gain	*1.85	----
Maximum Control Grid Current	$2.5x10^{-15}$	amp

* Gain tested with Grid 2 connected to plate;
Eb = 22.5 Vdc; Ec1 = -3 Vdc; RL = 200K ohms.

TERMINAL CONNECTIONS

Lead 1 Plate
Lead 2 Screen grid
Lead 3 Filament positive, one deflector
Lead 4 Filament negative, one deflector
Leads 5 and 6 Cut, no connection
Lead 7 Control grid
Lead 8 Cut, no connection

OBJECTIVE DATA

These data identify a particular development design; the type, including the type designation, is subject to change or abandonment.

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A | QV290 | SHEET: 1 | REVISION: 1

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND
1	TUBE ASSEMBLY	T3 Button	201565	(1)		
2						
3	Bulb Assembly (Cut)		20874-18	(1)		5114
4	Bulb Assembly (Unfinished)		20874-1	(1)		
5	Tube-Glass (Bulb)	.310 I.D.x.033Wallx76.0mm CL 8160 Glass	200016-3	1	502-001	
6	Tube-Glass (Exhaust)	Class .145 x 82.0mm C.L. 0120 Glass	5425-57	1	502-001	
7						
8	Solder	63% Sn - 37% Pb Ingot	201101-632	AsReq	004-001	5078
9						
10	Paint		-	AsReq		5022
1	Tube Marking	Per Tube Marking Index	8633	-		
2						
3	MOUNT ASSEMBLY		201564	(1)		
4						
5	Stem Assembly (Cut)		200412-46	(1)		5107
6	Stem Assembly (Unfinished)		200412-1	(1)		
7	Lead	.018 Dia. x 69.5mm C.L. Dumet	201102-742	8	001-016	
8	Tube-Glass	Class .350 x .560 gm. 0120 Glass	5425-108	1	502-001	
9						
20	Spacer (Coated-Bottom)		201535-2	(1)		5034-038
1	Coating		-	AsReq		
2	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
3						
4	Spacer (Coated-Bottom)	Intermediate	201535-2	(1)		5034-038
5	Coating		-	AsReq		
6	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
7						
8	Grid Assembly #1		7724-47	(1)		5033-202
9	Wire (Winding)	.001 Dia. H.B.	201102-629	AsReq	.001-002	
30	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
1						
2	Grid Assembly #2		5399-64	(1)		5033-202
3	Wire (Winding)	.0016 Dia. H.B.	201102-631	AsReq	.001-002	
4	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
5						

REVISIONS

POC 66-5103
Mt. Assy.
Comp. Added
Sh. 2 Added
5-26-66 1

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A | QV290 | SHEET: 2 | REVISION: 0

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND.
36	Spacer-Deflector-Spring Assembly		201563-2	(1)		
7	Spacer (Coated-Top)		201535-2	(1)		5034-038
8	Coating		-	AsReq		
9	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
40	Spacer (Coated-Top)	Intermediate	201535-2	(1)		5034-038
1	Coating		-	AsReq		
2	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
3	Plate (Deflector)	.005 Nickel	9465-1	1	205-002	5053-202
4	Wire-Bent (Support)	.020 Dia. Nickel	9496-1	1	205-002	5053-203
5	Spring (Filament)	8.23-8.57mg./200mm CLS-218 Tungsten	21119-1	1	001-004	5053
6						
7	Plate (Deflector)	.005 Nickel	9465-1	1	205-002	5053-203
8						
9	Plate	.005 Nickel	9283-1	2	205-002	5053-203
50						
11	Filament Assembly	RCA Converted Machine 15.0mm Connector	21252-38	(1)		
2	Ribbon (Connector)	.0015 x .591 x .020 CL 80-20 NiCr	201106-699	AsReq	003-002	
3	Filament Wire (Coated)	25.0mm CL	5167-133	(1)		5009
4	Coating		-	AsReq		
5	Filament Wire (Etched)	.120-.128mg./200mm	205167-133	AsReq		5102
6	Wire-Tungsten	.32-.34Mg./200mm	201103-602	AsReq	001-016	
7						
8	Shield (Bottom Filament Support)	.005 Nickel	21077-1	1	205-002	5053-203
9						
60	Ribbon-Cut (Plate Connector-Bottom)	.002 x .010 x 5.0mm CL Nickel	208380-7	1	003-004	5053-204
1						
2	Ribbon-Cut (Grid #1 Connector-Bottom)	.002 x .010 x 5.0mm CL Nickel	208380-7	1	003-004	5053-204
3						
4	Ribbon-Cut (Grid #2 Connector-Bottom)	.002 x .010 x 5.0 mm CL Nickel	208380-7	1	003-004	5053-204
5						
6	Ribbon-Cut (Filament Conn.-Bottom)	.002 x .010 x 5.0mm CL Nickel	208380-7	2	003-004	5053-204
7						
8	Ribbon-Cut (Support Stop)	.005 x .020 x 2.0mm CL Nickel	208324-33	4	003-004	5053-204
9						
70						

REVISIONS

POC 66-5103
Mt. Assy.
Comp. added
5-26-66 0

RAYTHEON COMPANY INDUSTRIAL COMPONENTS DIVISION	201565 REV. 2

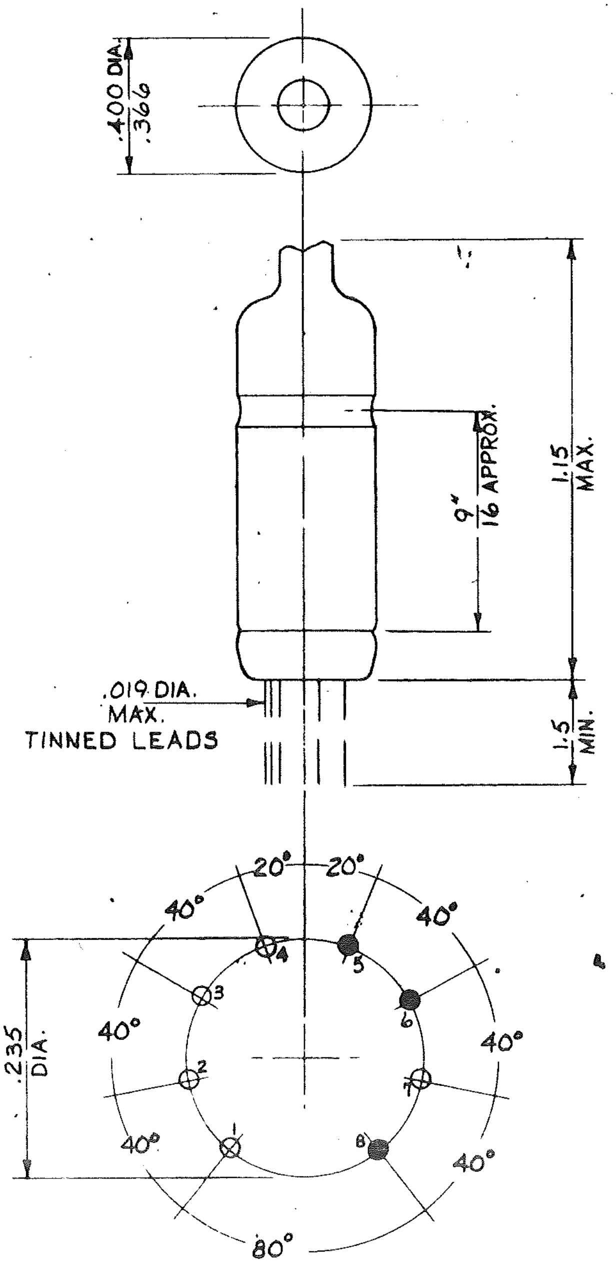
TUBE ASSEMBLY

T3 BUTTON TYPE.
8 LEADS UNSHIELDED.

TERMINAL CONNECTIONS

TUBE TYPE NUMBER	TERMINAL NUMBERS							
	1	2	3	4	5	6	7	8
QV290	P	G_2	F+	F–	–	–	G_1	–

A
18.145
30.114
31.4
QV290



A.- TUBE MARKING BRAND TO BE LOCATED JUST BELOW DENT IN TUBE.

B.- LEADS 5, 6 & 8 INDICATED BY DARKENED CIRCLES ARE CUT OFF NO GREATER THAN .020 FROM PROTRUSION.

REVISIONS	
POC64-5188. rjs 6·18·64.	0
POC 64-5231 TYPE QV290 ADDED. AJ 9-15-64	1
POC66-5103. T.T. QV292 REM. R 5-25-66.	

"A" SIZE SPECIFICATION FORM NO. CH-48-TC 5-61

RAYTHEON

SUBMINIATURE ELECTROMETER PENTODE QV291

Raytheon experimental type QV291 is a subminiature electrometer pentode with very low filament power, good emission stability, low microphonics, and low grid current. This is a metal-ceramic construction version of type 8520.

ELECTRICAL DATA

ABSOLUTE MAXIMUM RATINGS

	UNITS	
Filament Voltage (dc)	0.625	±10%
Plate Voltage	45	volts
Screen Grid Voltage	45	volts
Total Cathode Current	100	uAdc

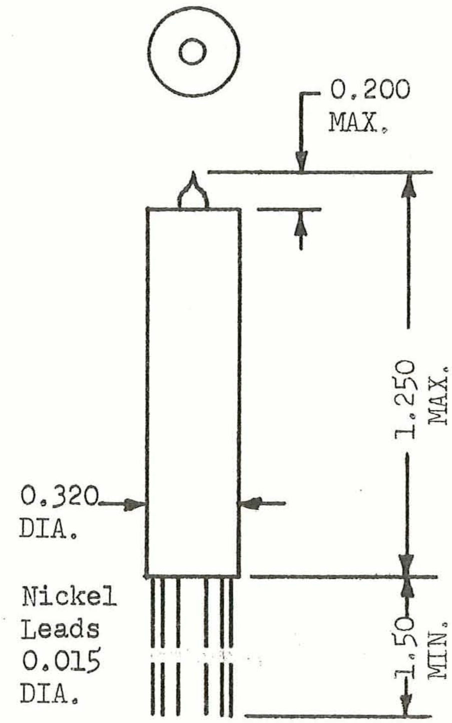
TYPICAL CHARACTERISTICS

Filament Voltage	0.625	volts
Filament Current	10	mA
Plate Voltage	8	volts
Screen Grid Voltage	5.5	volts
Control Grid Voltage	-2.0	volts
Plate Load Resistance	---	ohms
Plate Current	8	uAdc
Screen Grid Current	2.5	uAdc
Amplification Factor (Grid 2 Conn. to Plate)	2.2	----
Transconductance	17	umho
*Voltage Gain	*1.85	----
Maximum Control Grid Current	2.5×10^{-15}	amp

* Gain tested with Grid 2 connected to plate; Eb = 22.5 Vdc; Ec1 = -3 Vdc; RL = 200K ohms.

MECHANICAL DATA

Envelope .... Metal
Base ... Ceramic Header
Mounting Position . Any



TERMINAL CONNECTIONS

Lead 1 Plate
Lead 2 Screen grid
Lead 3 Filament positive, one deflector
Lead 4 Filament negative, one deflector
Leads 5 and 6 Omitted
Lead 7 Control grid

OBJECTIVE DATA

These data identify a particular development design; the type, including the type designation, is subject to change or abandonment.

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A | QV291 | SHEET: 1 | REVISION: 1

DEVELOPMENTAL

DIST.: A, 18.146, 30.115, 5, 15, 23, 24, 31.5, 38

DIMENSIONS IN INCHES UNLESS NOTED

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M.	OPERATION	STAND.
1	TUBE ASSEMBLY	=	201567	(1)			
2							
3	SEAL-IN (Before Exhaust)		201568-2	(1)			
4							
5	TUBE-METAL (Bulb)	.2945 I.D.x.010 Wallx1.030 C.L.Smls. Nickel	207989-56	1			
6							
7	MOUNT ASSEMBLY (With Exhaust Cap & Stem)		201569-2	(1)			
8							
9	CAP ASSEMBLY (Exhaust)		201570-2	(1)			
10	Wire (Brazing Ring)		201190-34	(1)			
1	Wire (Bulk)	.010 Dia. Cusil (Decarbonized)	201102-879	AsReq			
2	Tube-Metal (Exhaust)	.125 O.D.x.020 Wallx3.000C.L.OFHC Copper	207989-57	1			
3	Cap	.010 Grade "A" Nickel	201571-1	1			
4							
5	STEM ASSEMBLY (Cut)		201572-2	(1)			
6	Stem Assembly (Unfinished)		201572-1	(1)			
7	Wire-Brazing Ring (Leads)		—				
8							
9	Wire (Brazing Ring)		—				
20			—				
1	Wire-Bulk (Lead)	.015 Dia. Nickel	201102-602	AsReq			
2	Tube-Metal (Sealing Ring)	.2815 I.D.x.005Wallx.225C.L. Smls.Nickel	207989-58	1			
3	Insulator-Stem (Metalized & Plated)		201573-2	(1)			
4	Metalizing		—	AsReq			
5	Plating		—	AsReq			
6	Insulator (Stem)	99% Alumina	201573-1	1			
7							
8	MOUNT ASSEMBLY (With Sealing Ring)		201574-2	(1)			
9							
30	Wire (Brazing Ring)		201190-36	(1)			
1	Wire (Bulk)	.015 Dia. Cusil (Decarbonized)	201102-887	AsReq			
2							
3	Tube-Metal (Sealing Ring-Reop).		26212-1	(1)			
4	Tube-Metal (Sealing Ring)	.282 I.D. x .005W x .315 CL Seamless Nickel	207989-59	1			
5	MOUNT ASSEMBLY		201575	(1)			

REVISIONS

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POC 66-5149
7-28-66 I

CM-23-M

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A — QV291 — SHEET 2 — REVISION 0

DEVELOPMENTAL

DIST.: A, 18.146, 30.115, 5, 15, 23, 24, 31.5, 38

DIMENSIONS IN INCHES UNLESS NOTED

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND.
36	Spacer (Bottom)	99 + % Alumina	201405-1	1		
7						
8	Grid Assembly #1		7724-47	(1)		5033-202
9	Wire (Winding)	.001 Dia. HB	201102-629	AsReq	001-002	
40	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
1						
2	Grid Assembly #2		7724-54	(1)		5033-202
3	Wire (Winding)	.0016 Dia. HB	201102-631	AsReq	001-002	
4	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
5						
6	Plate (Deflector)	.005 Nickel	201548-1	2	205-002	5053-203
7						
8	Plate Assembly		201576-2	(2)		
9	Ribbon - Cut (Plate)	.270 C.L.	208313-83	(1)		5053-203
50	Ribbon (Bulk)	.005 x .093 Nickel (¼ Hard)	201105-801	AsReq	205-002	
1	Wire-Cut (Support)	.410 C.L.	208301-59	(2)		
2	Wire (Bulk)	.020 Dia. Nickel (¼ Hard)	201102-641	AsReq	001-026	
3						
4	Ribbon-Cut (Deflector Stop-Bottom)	3.5 mm. C.L.	208390-13	(1)		5053-204
5	Ribbon (Bulk)	.005 x .040 Nickel	201105-693	AsReq	003-004	
6						
7	Ribbon-Cut (Plate Stop)	2.5 mm C.L.	208312-35	1		5053-204
8	Ribbon (Bulk)	.005 x .030 Nickel	201105-684	AsReq	003-004	
9						
60	Spacer (Top-Metalized)		201405-2	(1)		
1	Metalizing		-	AsReq		
2	Spacer (Top)	99 + % Alumina	201405-1	1		
3						
4	Ribbon-Cut (Strap)	3.5 mm C.L.	208390-13	1		5053-204
5	Ribbon (Bulk)	.005 x .040 Nickel	201105-693	AsReq	003-004	
6						
7	Wire-Bent (Spring Support)	.020 Dia. Nickel	9217-1	1	205-002	5053-203
8						
9	Spring (Filament)	8.23-8.57mg/200mm CLS-218 Tungsten	21119-1	1	001-004	5053
70						

REVISIONS

POC 64-5197
AJ
7-30-64 — r/s 0

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RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

QV291 — DEVELOPMENTAL

SHEET 3 — REVISION 0

DIST.: ▲ 18.146, 30.115, 5, 15, 23, 24, 31.5, 38

DIMENSIONS IN INCHES UNLESS NOTED

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND.
71	Filament Assembly	RCA Converted Maching 15.0mm Connector	21252-38	(1)		
2	Ribbon-Bulk (Connector) ALT. below	.0015x.591 x .020 C.L. 80-20 NiCr	201106-699	AsReq	003-002	
3	Filament Wire (Coated)	25.0mm C.L.	5167-133	1		5009
4	Coating		-	AsReq		
5	Filament Wire (Etched)	.120-.128mg/200mm	205167-133	AsReq		5102
6	Wire (Bulk)	.32-.34 mg/200mm Tungsten	201103-602	AsReq	001-006	
7						
8	Shield (Filament Support-Bottom) .005 Nickel		21117-1	1	205-002	5053-203
9						
80	Ribbon-Cut	5.0mm C.L.	208324-31	1		5053-204
1	Ribbon (Bulk)	.005 x .020 Nickel	201105-683	AsReq	003-004	
2						
3						
4						
5		ALTERNATES FOR PREFERRED PARTS:				
6	Ribbon-Bulk (Connector)		201106-674			
7						
8						
9						
90						
1						
2						
3						
4						
5						
6						
7						
8						
9						
100						
1						
2						
3						
4						
5						

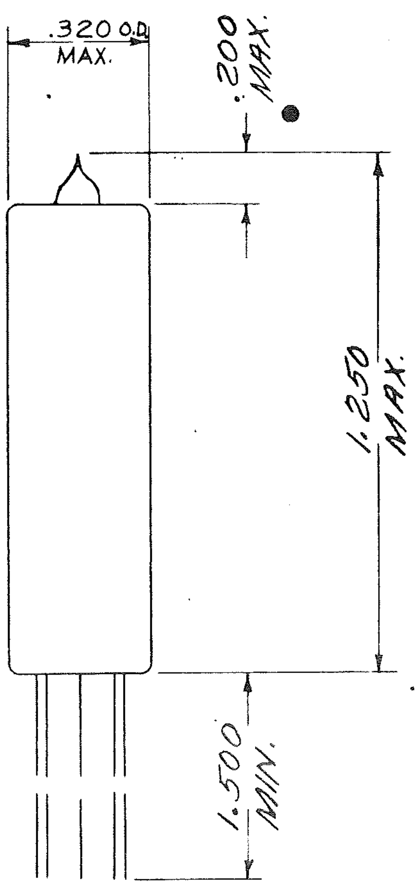
REVISIONS

FOC 64-5197
AJ
7-30-64 — rjs 0

	RAYTHEON COMPANY INDUSTRIAL COMPONENTS DIVISION	201567 — REV. 2
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED DIMENSIONS IN INCHES UNLESS NOTED DO NOT SCALE PRINT	TUBE ASSEMBLY QV291	QUANTITIES REQUIRED PER GROUP GROUP

A
18.146
30.115
31.4

	BILL OF MATERIAL	REFERENCE DRAWING



TERMINAL CONNECTIONS

TUBE TYPE NUMBER	TERMINAL NUMBER 1	2	3	4	5	6	7
QV291	P	G_2	F+BOT.	F-TOP	-	-	G_1

REVISIONS

POC 64-5197. rjs 6·30·64.	0
POC 64-5222. TERMINAL CONNECTION TABLE REVISED. TERMINAL #3 WAS F - TOP. TERMINAL #4 WAS F+ BOTTOM. rjs 8·27·64.	1
POC 66-5147 7-28-66	2

"A" SIZE SPECIFICATION FORM NO. CH-48-TC 5-61

RAYTHEON

SUBMINIATURE ELECTROMETER SPACE CHARGE PENTODE QV292

Raytheon experimental type QV292 is a subminiature electrometer space charge pentode with very low filament power, good emission stability, low microphonics, and low grid current.

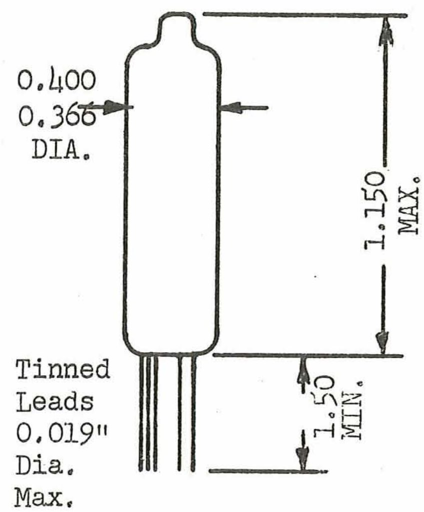
ELECTRICAL DATA

TYPICAL CHARACTERISTICS

			UNITS
Filament Voltage	0.625	0.625	volts
Filament Current	10	10	mA
Plate Voltage (Grid 3 tied to Plate)	6	6	Vdc
Space Charge Grid Voltage (Grid 1)	+2.5	+3.4	Vdc
Control Grid Voltage (Grid 2)	-2.5	-2.5	Vdc
Plate Resistance	90	65	Kohm
Plate Current	15	21	uAdc
Space Charge Grid Current	140	250	uAdc
Transconductance	19	24	umho
Control Grid Current	2.5×10^{-15}	--	A

MECHANICAL DATA

Envelope .... T3 Glass
Base .... Button E8-10
Mounting Position . Any



TERMINAL CONNECTIONS

Lead 1	Plate
Lead 2	Grid #3
Lead 3	Filament positive
Lead 4	Filament negative
Lead 5	Grid #1 (Space-Charge)
Lead 6	Cut, no connection
Lead 7	Grid #2 (CONTROL)
Lead 8	Cut, no connection

EXPERIMENTAL DATA

These data identify a particular development design; the type, including the type designation, is subject to change or abandonment.

RAYTHEON COMPANY

PARTS LIST

CONSTR A

QV292

SHEET 1 REVISION 3

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

ITEM	TE AND DESCRIPTION		DWG NO	QUAN	M S	
1	TUBE ASSEMBLY		26163	(1)		
2						
3	Bulb Assembly (Cut)		20874-18	(1)		5114
4	Bulb Assembly (Unfinished)		20874-1	(1)		
5	Tube-Glass (Bulb)	.310 I.D. x .033Wall x 76.0mmCL 8160 Glass	200016-3	1	502-001	
6	Tube-Glass (Exhaust)	Class .145 x 82.0mm CL 0120 Glass	5425-57	1	502-001	
7						
8	Solder	63% Sn - 37% Pb Ingot	201101-632	AsReq	004-001	5078
9						
10	Paint		-	AsReq		5022
1	Tube Marking	Per Tube Marking Index	8633	-		
2						
3	MOUNT ASSEMBLY		26164	(1)		
4						
5	Stem Assembly (Cut)		200412-42	(1)		5107
6	Stem Assembly (Unfinished)		200412-1	(1)		
7	Lead	.018 Dia. x 69.5mm CL Dumet	201102-742	8	001-016	
8	Tube-Glass	Class .350 x .560gm 0120 Glass	5425-108	1	502-001	
9						
20	Spacer (Coated-Bottom)		201535-2	(1)		5034-038
1	Coating		-	AsReq		
2	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
3						
4	Spacer (Coated-Bottom)	Intermediate	201535-2	(1)		5034-038
5	Coating		-	AsReq		
6	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
7						
8	Grid Assembly #1		7724-47	(1)		5033-202
9	Wire (Winding)	.001 Dia. H.B.	201102-629	AsReq	001-002	
30	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
1						
2	Grid Assembly #2		7724-53	(1)		5033-202
3	Wire (Winding)	.0016 Dia. H.B.	201102-631	AsReq	001-002	
4	Wire (Support)	.0155 Dia. Nickel Plated Steel	201102-735	AsReq	001-017	
5						

REVISIONS

POC 66-5104
5-26-66 3

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A | QV292 | SHEET: 2 | REVISION: 1

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

DIST

CUT HERE GUARANTEED

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND
36	Grid Assembly #3		7724-56	(1)		5033-202
7	Wire (Winding)	.0025 Dia. H.B.	201102-634	AsReq	001-002	
8	Wire (Support)	.020 Dia. Nipron	201102-637	AsReq	001-017	
9						
40	Spacer-Deflector-Spring Assembly		201563-2	(1)		
1	Spacer (Coated-Top)		201535-2	(1)		5034-038
2	Coating		-	AsReq		
33	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
4	Spacer (Coated-Top)	Intermediate	201535-2	(1)		5034-038
5	Coating		-	AsReq		
6	Spacer	Good Stained Mica	201535-1	1	205-003	5202-065
7	Plate (Deflector)	.005 Nickel	9465-1	1	205-002	5053-202
8	Wire-Bent (Support)	.020 Dia. Nickel	9496-1	1	205-002	5053-203
9	Spring (Filament)	8.23-8.57mg./200mm CLS-218 Tungsten	21119-1	1	001-004	5053
50						
1	Plate (Deflector)	.005 Nickel	9465-1	1	205-002	5053-203
2						
3	Plate	.005 Nickel	9283-1	2	205-002	5053-203
4						
5	Filament Assembly	RCA Converted Machine 15.0mm Connector	21252-38	(1)		
6	Ribbon (Connector)	.0015 x .591 x .020 CL 80-20 NiCr	201106-699	AsReq	003-002	
7	Filament Wire (Coated)	25.0mm CL	5167-133	(1)		5009
8	Coating		-	AsReq		
9	Filament Wire (Etched)	.120-.128mg./200mm	2005167-133	AsReq		5102
60	Wire-Tungsten	.32-.34mg./200mm	201103-602	AsReq	001-016	
1						
2	Shield (Bottom Filament Support)	.005 Nickel	21077-1	1	205-002	5053-203
3						
4	Ribbon-Cut (Plate Connector Bottom)	.002 x .010 x 5.0mm CL Nickel	208380-7	1	003-004	5053-204
5						
6	Ribbon-Cut (Grid #1 Connector Bottom)	.002 x .010 x 5.0 mm CL Nickel	208380-7	1	003-004	5053-204
7						
8	Ribbon-Cut (Grid #2 Connector Bottom)	.002 x .010 x 5.0mm CL Nickel	208380-7	1	003-004	5053-204
9						
70	Ribbon-Cut (Filament Conn. Bottom)	.002 x .010 5.0mm CL Nickel	208380-7	2	003-004	5053-204
1	Ribbon-Cut (Support Strap)	.005 x .020 x 2.0mm CL Nickel	208324-33	4	003-004	5053-204

REVISIONS

POC 66-5
5-26-66 1

CH-23-M

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

A26163 REV. O

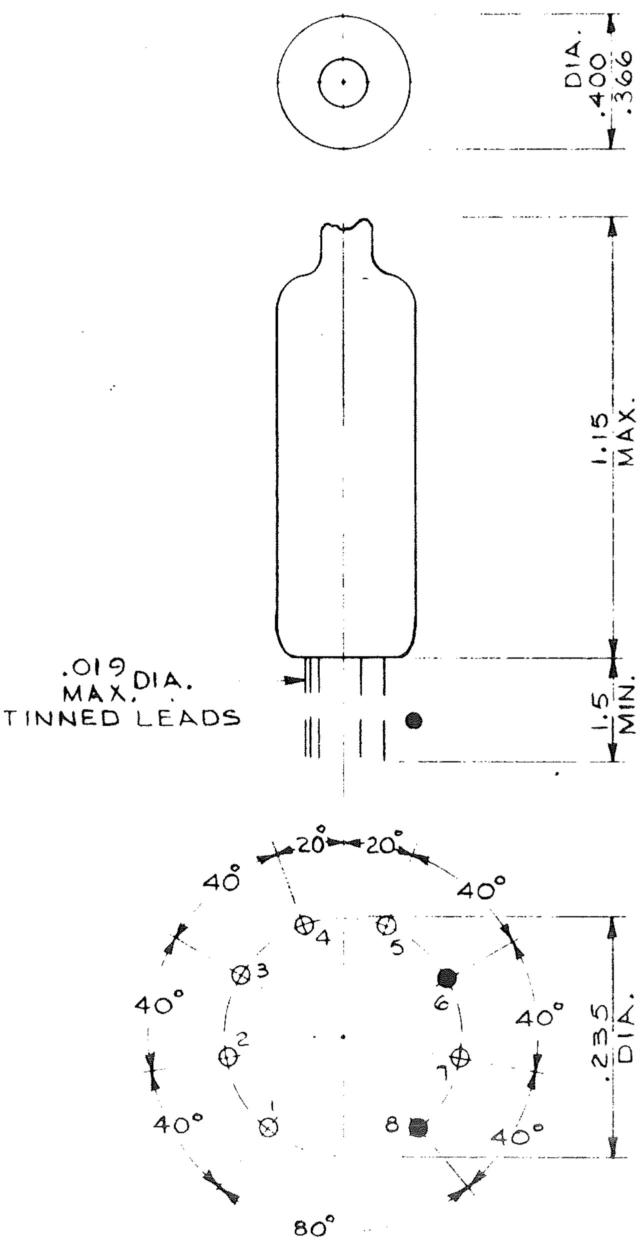
TUBE ASSEMBLY

T3 BUTTON TYPE
8 LEADS UNSHIELDED

TERMINAL CONNECTIONS

TUBE TYPE NUMBER	TERMINAL NUMBERS							
	1	2	3	4	5	6	7	8
QV292	P	G_3	F_+	F_-	G_1	–	G_2	–

A
18.145
30.114
31.4



NOTES:
A.-

B.- LEADS 6 & 8 INDICATED BY DARKENED CIRCLES ARE CUT OFF NO GREATER THAN .020 PROTRUSION.

REVISIONS

REDRAWN. NOTE "A" & DIM. 9/16" APPROX. REMOVED. DWG. REV. PIC. TO AGREE.
R
12.9.66. O

"A" SIZE SPECIFICAT. FORM NO. CM-48-TC 5-61

RAYTHEON

SUBMINIATURE ELECTROMETER TRIODES

QV293
QV309

Raytheon experimental types QV293 and QV309 are subminiature triodes, featuring geometry changes from conventional design, with the objective of improvement of grid current levels for use in electrometer circuits. In these tubes the function by the control grid and anode, as these terms are normally used, is reversed; i.e. the outer solid element, normally the anode-plate, becomes the control element, and the inner spiral, normally the control grid, assumes the function of the anode element.

ELECTRICAL DATA

INTER-ELECTRODE CAPACITANCES

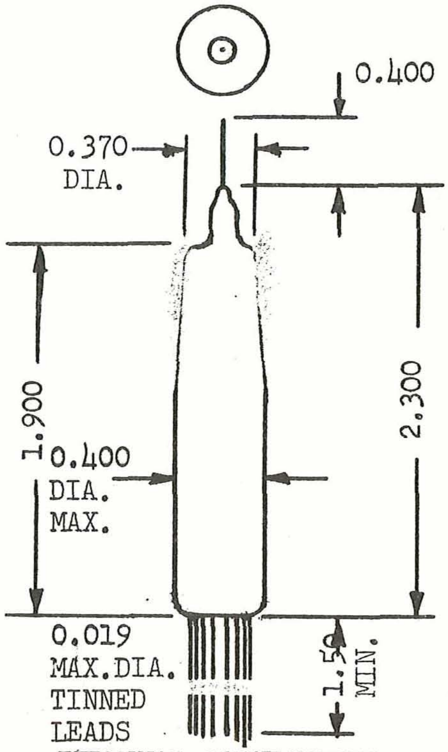
	TYPE QV293	TYPE QV309	UNITS
Capacitance, control element to anode	3.1	2.5	pf
Capacitance, control element to filament	1.4	1.4	pf
Capacitance, anode to filament ..	0.66	0.62	pf

ELECTRICAL CHARACTERISTICS

Filament Voltage	1.1	1.1	volts
Filament Current	13.0	13.0	mA
Anode Voltage	4.0	9.0	Vdc
Control Voltage	-6.0	-2.5	Vdc
Anode Current	150	400	uAdc
Control Electrode Current	1x10-14	1x10-13	A
Amplification Factor	0.30	0.75	----
Transconductance	60	150	umho

MECHANICAL DATA

Envelope .... Special T3 Glass
Base ...... Button E8-10
Mounting Position .. Any



TERMINAL CONNECTIONS

Lead 1 No connection
Lead 2 No connection
Lead 3 Filament positive
Lead 4 No connection
Lead 5 Anode
Lead 6 Filament, negative
Lead 7 No connection
Lead 8 No connection
Top Cap Control element

OBJECTIVE DATA

These data identify particular development designs; the types, including the type designations, are subject to change or abandonment.

DIMENSIONS IN INCHES
UNLESS NOTED

DEVELO. MENTAL

PARTS LIST

CONSTR A | QV293 | SHEET 1 | REVISION 0

ITEM	TITLE AND DESCRIPTION		DWG. NO	QUAN		
1	TUBE ASSEMBLY		26198	(1)		
2						
3	Bulb Assembly (Cut)		26197-2	(1)		
4	Bulb Assembly		26196-2	(1)		
5	Tube-Glass (Bulb)	.310 I.D.x.033W x 76.0mm CL 8160 Glass	200016-3	1	502-001	
6	Tube-Glass (Exh.)	Class .145 x 82.0mm CL 0120 Glass	5425-57	1	502-001	
7						
8	Solder	63/37 Ingot	201101-632	x	004-001	5078
9	Paint			x		
10	Tube Marking	Per Tube Marking Index	8633	-		
1						
2	MOUNT ASSEMBLY		26195	(1)		
3						
4	Stem Assembly (Cut)		200412-48	(1)		
5	Stem Assembly		200412-1	(1)		
6	Lead	.018 Dia. x 69.5mm CL Dumet	201102-742	8	001-016	
7	Tube-Glass	Class .350 x .560Gm. 8160 Glass	5425-108	1	502-001	
8						
9	Spacer (Ctd.-Bottom)		25964-2	(1)		5034-5038
20	Coating			x		
1	Spacer	.008-.012 Thk. Good Stained Mica	25964-1	1	205-003	5202-5065
2						
3	Grid (Anode Assembly)		5396-80	(1)		5033-5202
4	Wire (Winding)	.001 Dia. HB	201102-629	x	001-002	
5	Wire (Support)	.0155 Dia. Ni. Pl. Steel	201102-735	x	001-017	
6						
7	Tube-Rod Assembly (Control Assembly)		26194-2	(1)		
8	Rod	96% Alumina	26193-1	2		
9	Tube-Metal	.005 Grade "A" Nickel	25966-1	1		
30	Clip		26192-1	2		
1						
2	Ribbon-Stop (Formed)		26191-1			
3	Ribbon-Cut	.002 x .050 x 5.5mm CL Nickel	208313-86			
4	Support (Spacer)	.005 Gr. "A" Nickel	25968-1	2		
5	Wire-Bent (Filament Support)	.020 Dia. Nickel	26190-1	1		

REVISIONS

POC 66-5131
6-8-66 0

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A | QV293 | SHEET: 2 | REVISION: 0

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

CUT HERE GUARANTEED

DIST

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND
36	Wire-Bent (Support)	.020 Dia. Nickel	26189-1			
7	Spring (Filament)	7.35-7.6Mg./200mm x 15.0mm CL Tungsten	7460-31	1	001-004	5053
8	Connector (Filament)	.007 Nickel	25967-1	1	205-002	5053-5203
9	Wire-Bent (Control Element)		26188-1	1	001-016	
40	Ribbon-Cut (Anode Strap)	.002 x .010 x 5.0mm CL	208380-7	1		
1	Wire-Cut (Ceramic Rods)	.010 Dia. Nickel		4		
2	Getter		9499-1	1	205-002	
3						
4	Filament Assembly		23874-46	(1)		
5	Ribbon (Connector)	.0015 x 1.000 x .020 CL 80-20 Ni Cr	201106-750	1	003-002	
6	Filament Wire (Ctd.)	45.5mm CL	5167-185	(1)		
7	Coating	C81-16		x		
8	Filament Wire (Etched)	.218-.238mg./200mm	205167-184			
9	Wire-Tungsten	.320-.340mg./200mm	201103-602	x	001-005	
50						
1						
2						
3						
4						
5						
6						
7						
8						
9						
60						
1						
2						
3						
4						
5						
6						
7						
8						
9						
70						

REVISIONS

POC 66-5131
6-8-66 0̄

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR A — QV309 — SHEET 1 — REVISION 0

DEVELOPMENTAL

DIMENSIONS IN INCHES UNLESS NOTED

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND.
1	TUBE ASSEMBLY		26198	(1)		
2						
3	Bulb Assembly (Cut)		26197-2	(1)		
4	Bulb Assembly		26196-2	(1)		
5	Tube-Glass (Bulb)	.310 I.D. x .033 W x 76.0mm CL 8160 Glass	20001603	1	502-001	
6	Tube-Glass (Exh.)	Class .145 x 82.0mm CL 0120 Glass	5425-57	1	502-001	
7						
8	Solder	63/37 Ingot	201101-632	x	004-001	5078
9	Paint			x		
10	Tube Marking	Per Tube Marking Index	8633	–		
1						
2	MOUNT ASSEMBLY		26195	(1)		
3						
4	Stem Assembly (Cut)		200412-48	(1)		
5	Stem Assembly		200412-1	(1)		
6	Lead	.018 Dia. x 69.5mm CL Dumet	201102-742	8	001-016	
7	Tube-Glass	Class .350 x .560Gm. 8160 Glass	5425-108	1	502-001	
8						
9	Spacer (Ctd.-Bottom)		25964-2	(1)		5034-5038
20	Coating			x		
1	Spacer	.008-.012 Thk. Good Stained Mica	25964-1	1	205-003	5202-5065
2						
3	Grid (Anode Assembly)		5396-81	(1)		5033-5202
4	Wire (Winding)	.001 Dia. HB	201102-629	x	001-002	
5	Wire (Support)	.0155 Dia. Ni. Pl. Steel	201102-735	x	001-017	
6						
7	Tube-Rod Assembly (Control Assembly)		26194-2	(1)		
8	Rod	96% Alumina	26193-1	2		
9	Tube-Metal	.005 Grade "A" Nickel	25966-1	1		
30	Clip		26192-1	2		
1						
2	Ribbon-Stop (Formed)		26191-1			
3	Ribbon-Cut	.002 x .050 x 5.5mm CL Nickel	208313-86			
4	Support (Spacer)	.005 Gr. "A" Nickel	25968-1	2		
5	Wire-Bent (Filament Support)	.020 Dia. Nickel	26190-1	1		

REVISIONS

POC 66-5143
7-20-66 — 0

I-23

CH-23-M

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR. A | QV309 | SHEET 2 | REVISION 0

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

CUT HERE GUARANTEED ± 5.6

DIST.

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND
36	Wire-Bent (Support)	.020 Dia. Nickel	26189-1			
7	Spring (Filament)	7.35-7.6Mg./200mm x 15.0mm CL Tungsten	7460-31	1	001-004	5053
8	Connector (Filament)	.007 Nickel	25967-1	1	205-002	5053-5203
9	Wire-Bent (Control Element)		26188-1	1	001-016	
40	Ribbon-Cut (Anode Strap)	.002 x .010 x 5.0mm CL	208380-7	1		
1	Wire-Cut (Ceramic Rods)	.010 Dia. Nickel		4		
2	Getter		9499-1	1	205-002	
3						
4	Filament Assembly		23874-46	(1)		
5	Ribbon (Connector)	.0015 x 1.000 x .020 CL 80-20 Ni Cr	201106-750	1	003-002	
6	Filament Wire (Ctd.)	45.5mm CL	5167-185	(1)		
7	Coating	C81-16		x		
8	Filament Wire (Etched)	.218-.238Mg./200mm	205167-184			
9	Wire-Tungsten	.320-.340Mg./200mm	201103-602	x	101-005	
50						
1						
2						
3						
4						
5						
6						
7						
8						
9						
60						
1						
2						
3						
4						
5						
6						
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8						
9						
70						

REVISIONS

POC 66-5143
7-20-66 — 0

I-24

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18.156
30.120
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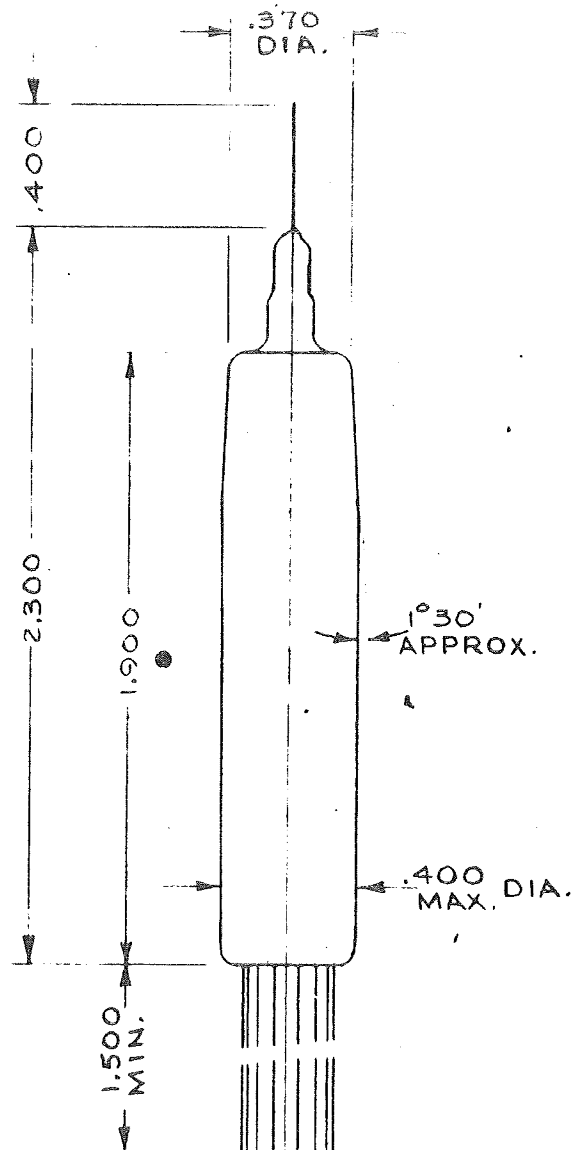
QV309
QV293

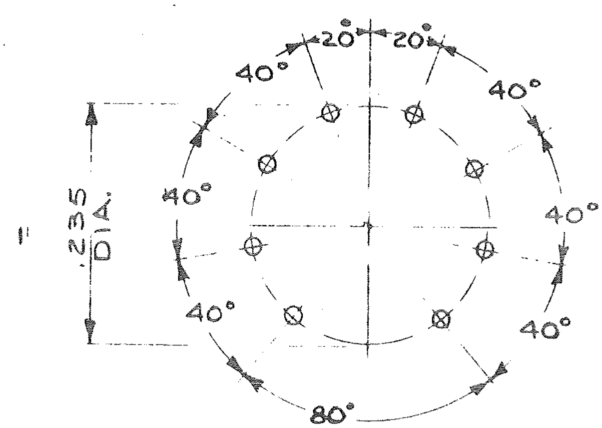
"A" SIZE SPECIFIC. FORM NO. CM-48 TC 5-61

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

A26198 REV. 1

TUBE ASSEMBLY





TERMINAL CONNECTIONS

TUBE TYPE	TERMINAL NUMBER 1	2	3	4	5	6	7	8	TOP CAP
QV293	NC	NC	F+ BOT.	NC	ANODE	F- TOP	NC	NC	CONTROL ELEMENT
QV309	NC	NC	F+ BOT	NC	ANODE	F- TOP	NC	NC	CONTROL ELEMENT

REVISIONS	
POC 66-5131. 6-21-66.	0
POC 66-5143 QV309 ADDED 7-20-66	1

RAYTHEON

TECHNICAL INFORMATION SERVICE

Technical Information

QV331

MINIATURE ELECTROMETER TETRODE

Raytheon Type QV331 is a cathode-type tetrode designed for use as an electrometer tube, particularly as a high gain current amplifier in applications where the input signal is of the order of micro-micro-amperes. As with other tubes of this class, shielding from electrical and magnetic fields, as well as from all forms of radiant energy is recommended. Precautions of cleanliness, humidity and temperature control, especially of other components in the circuit such as the dielectrics in the exterior portion of the grid circuit, should be rigidly observed.

ELECTRICAL DATA

DIRECT INTERELECTRODE CAPACITANCES

		Units
Grid to Plate	0.12	pf
Input	2.20	pf
Output	1.55	pf

RATINGS, ABSOLUTE MAXIMUM VALUES

Heater Voltage (AC or DC)	2.5 ±10%	Volts
Plate Voltage	12	Volts
Screen Grid Voltage	12	Volts
Control Grid Voltage	0 to - 12	Volts
Heater-Cathode Voltage	±16	Volts
Cathode Current	50	uAmps

CHARACTERISTICS AND TYPICAL OPERATION

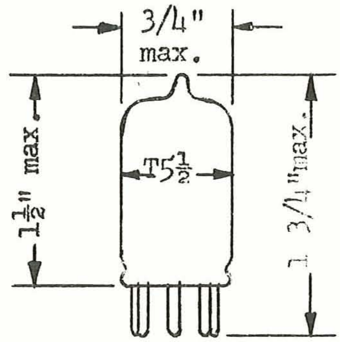
Heater Voltage	2.5	Volts
Heater Current	0.2	Amps
Plate Voltage	11.0	Volts
Grid No. 2 Voltage	11.0	Volts
Grid No. 1 Voltage	-2.2	Volts
Plate Current	18	uAmps
Grid No. 2 Current	4	uAmps
Transconductance	40	umhos
Plate Resistance	1	Megohm
Amplification Factor (triode)	4.1	--
Grid Current, maximum	3×10^{-14}	Amps
Grid Current, nominal	1×10^{-14}	Amps

These data identify a particular developmental tube design, and the type designation or the descriptive data are subject to change or abandonment.

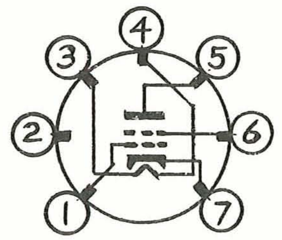
MECHANICAL DATA

Envelope.....T5½ Glass
Base...7 Pin Miniature Button
Outline....JEDEC (5-2)
Cathode....Coated Uni-Potential
Mounting Position..Any

PHYSICAL DIMENSIONS



BASING



BOTTOM VIEW

TERMINAL CONNECTIONS

Pin	Element
1	Grid No. 1
2	No Connection
3	Heater
4	Heater
5	Plate
6	Grid No. 2
7	Cathode

Printed in U.S.A.

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A | QV331 | SHEET: 1 | REVISION: 0

DIST

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

CUT HERE GUARANTEED

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND
1	TUBE ASSEMBLY	T5½ Button	20373	(1)		
2						
3	Bulb Assembly (Cut & Tubulated)		23453-18	(1)		5114
4	Bulb (Blank)	T5½ Gl Code 0081 Lime Glass	23453-1	1	502-001	
5	Tube-Glass (Exhaust)	Class .145 x 82.0mm CL 0120 Glass	5425-128	1	502-001	
6						
7	MOUNT ASSEMBLY		26148	(1)		
8						
9	Stem Assembly (Cut & Bent)		207224-22	(1)		
10	Stem Assembly (Unfinished)		207224-1	(1)		
1	Tube-Glass	Class .535 x .400 CL. 0120 Glass	5425-51	1	502-001	
2	Weld	2013¼ NPFE 8 (HD) -162D(L)-408Ni (Pointed)	8073-9	7	001-024	
33						
4	Spacer-Shield Assembly		26180-2	(1)		
5	Shield (Bottom)	.005 x .460 Steel	7910-1	1		5053-203
6	Spacer (Coated-Bot.)		26147-2	(1)		5034-038
7	Coating			x		
8	Spacer		26147-1	1	205-003	5202-065
9						
20	Heater (Coated)		26149-2	(1)		
1						
2	Cathode-Tab Assembly		200627-4	(1)		
3	Ribbon-Cut (Tab)	.003 x .006 x 6.0mm Nilvar	208313-61	1		5053-204
4	Cathode (Coated)		5398-313	(1)		
5	Coating	C41-2		x		
6	Cathode	.030 O.D. x 12.0mm CL SMLS #220 Alloy	206268-55	1	002-001	5094
7						
8	Grid Assembly #1		5400-281	(1)		5033-202
9	Winding Wire	.002 Dia. HB	201102-628	x	001-002	
30	Support Wire	.0155 Dia. NPS	201102-735	x	001-017	
1						
2	Grid Assembly #2		5400-282	(1)		5033-202
3	Winding Wire	.0025 Dia. HB	201102-634	x	001-002	
4	Support Wire	.0155 Dia. NPS	201102-735	x	001-017	
5						

REVISIONS

POC 66-5060
5-31-66 0

CH-23-M

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

PARTS LIST

CONSTR: A | QV331 | SHEET: 2 | REVISION: 0

DIMENSIONS IN INCHES UNLESS NOTED

DEVELOPMENTAL

CUT HERE GUARANTEED — 5-4

DIST

ITEM	TITLE AND DESCRIPTION		DWG. NO.	QUAN.	M. P.	OPERATION STAND
36	Ribbon-Cut (Connector)	.005 x .015 x 6.0mm Nickel	208311-3	1	003-004	5053-204
7	Ribbon-Cut (Connector)	.005 x .015 x 5.0mm Nickel	208311-45	1	003-004	5053-204
8	Plate	.005 x .500 W.B. Driver Duocarb	9205-3	1	205-002	5098-060-226
9						
40	Spacer-Shield Assembly (Staked)		26182-2	(1)		
1	Stake	.020 Dia. Nickel	208238-1	1	205-002	5053-203
2	Spacer-Shield Assembly		26181-2	(1)		
3	Shield	.005 x .460 Steel	7916-1	1	205-002	5053-204
4	Spacer (Coated)		26147-2	(1)		5034-038
5	Coating			x		
6	Spacer		26147-1	1	205-003	5202-065
7						
8	Getter Assembly		223558-6	(1)		
9						
50						
1						
2						
3						
4						
5						
6						
7						
8						
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60						
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REVISIONS

POC 66-5060
5-31-66 $\bar{0}$

CH-23-M

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18.130
18.154
30.13
30.16
30.101
30.119
31.2
31.4
36.6

DIMENSIONS IN INCHES UNLESS NOTED
DO NOT SCALE PRINT

TOLERANCES FOR DIMENSIONS UNLESS OTHERWISE MARKED

DIMENSION	FRACTION	DECIMAL
UP TO 1/2"	± 1/64"	± .005"
OVER 1/2"	± 1/32"	± .010"

RAYTHEON MANUFACTURING COMPANY

INDUSTRIAL TUBE DIVISION

A20375 REV. 4

TUBE ASSEMBLY

MINIATURE - 7 PIN
T5 1/2 BULB JETEC OUTLINE 5-1

QUANTITIES REQUIRED PER GROUP

GROUP

ITEM	BILL OF MATERIAL	FOR SUFFIX LETTER OF REF. DWG. NO. SEE DETAIL SHEET.	REFERENCE DRAWING

FOR TERMINAL CONNENTIONS SEE MOUNT ASSEMBLY 206794.

TERMINAL CONNECTIONS

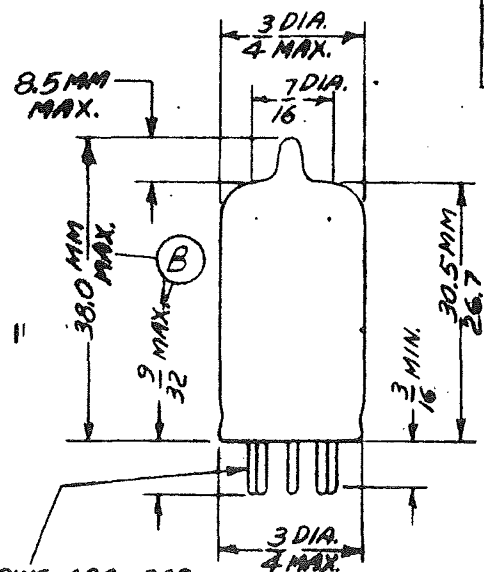
TUBE TYPE NUMBERS	PIN NUMBERS						
	1	2	3	4	5	6	7
6AK5	G1	K,IS,G3	H	H	P	G2	K,IS,G3
6AK5W	G1	K,IS,G3	H	H	P	G2	K,IS,G3
6C4W	P	NC	H	H	P	G	K
5654/6AK5W/6096	G1	K,IS,G3	H	H	P	G2	K,IS,G3
5725/6AS6W	G1	K, IS	H	H	P	G2	G3
5696	G1	K	H	H	G2	P	G2
QV331	G1	NC	H	H	P	G2	K

A. APPLY TUBE MARKING WITH BRAND AND COLOR PER CUSTOMER'S ORDER WITH BOTTOM OF MARKING 7/16" ABOVE BOTTOM OF GLASS.

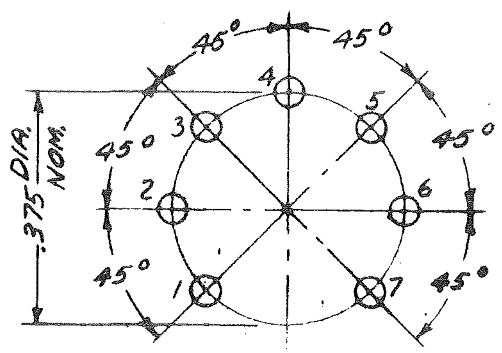
B. TUBES FOR ARMED SERVICES END USE MAY BE REQUIRED TO MEET OVERALL LENGTH OF 44.4MM WHICH IS LESS THAN SUM OF SEATED HEIGHT AND PIN LENGTH MAXIMUMS.

C. FOR ALIGNMENT USE GAUGE GE 7-1 (SEE 208794)

D. TIP DIMENSIONS TO BE CHECKED WITH GAUGE A223489.



7 PINS .038-.042 DIA. SPACED AS SHOWN BELOW.



BOTTOM VIEW

REVISIONS

POC66-5060.
T.T. QV331 ADDED.
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6-1-66. 4

APPENDIX II

EXPERIMENTAL TESTS PERFORMED DURING THE PROGRAM

Introduction

The following is a summary of tests W-12 through W-109 and W-1 through W-3 which were performed during this contract. A brief description of each test, its purpose, and the results obtained is included. If, in addition to the above information, significant data for a specific test is tabulated in Appendix III, this fact will be noted by a single asterisk beneath the test number. If graphs or curves are found in Appendix III for any given test, this fact will be signified by a double asterisk in the same place.

It should be noted that considerably more data on these tests and graphs of pertinent information were supplied in the thirty-four (34) monthly reports that were delivered on the contract.

At the end of each test, the exhaust and aging schedules for that test will be referenced by the notations EES...denoting the exhaust schedule, and EAS... the aging and stabilization schedule. Complete schedules referenced in this manner may be found in Appendix IV.

W-12 Dumet leads, sealed in regular CK587 envelopes composed of 0120 lead glass, which were subsequently evacuated and tipped off without a getter.

Purpose: To determine the magnitude and duration of the dielectric absorption current of the CK587 glass press as it affects drift characteristics of the CK587 electrometer tube.

Results: A large portion of the early turn-on drift in electrometer tubes does consist of dielectric absorption in the glass press. Upon the application of a voltage to the leads in apress, the resultant current is apparently composed of a displacement current due to capacitance - a current due to polarization of the glass and a leakage current due to the insulation resistance.

W-12 (contd.)

The displacement current only lasts for a very few minutes, while the current due to polarization of the glass may last for hours. Therefore, true leakage current can only be measured after a long stabilization period.

The data further indicated a need for proper annealing of the press in order to maintain high insulation resistance between leads, and the prevention of external mechanical stress on the leads or press in order to prevent the generation of piezoelectric charges in the glass envelope.

W-13

Standard CK587 structure with a gold plated control grid substituted for the regular HB nickel grid.

**

Purpose: To determine the effect of a gold plated control grid on tube characteristics, total observed grid current and the grid current crossover voltage.

Results: The data from this test was similar to the control lot, having approximately the same total grid current level and characteristic spread. One significant detail, which appeared to be the result of a change in the tube element work functions due to the gold plating, was the lowering of the grid current crossover voltage from -1.8 to about -1.6 volts.
Processing: EES-1, EAS-1.

W-14

Standard CK587 structure with a platinum plated control grid.

**

Purpose: To determine the effect of a platinum plated control grid on tube characteristics, total observed grid current, and the grid current crossover voltage.

Results: The results from this group were very much the same as those observed in test W-13. However, a still lower grid current crossover voltage of -1.4 to -1.5 volts was obtained; indicating a further change in the tube element work functions.
Processing: EES-1, EAS-1.

W-15-1

Standard CK587 structure processed without flashing getters.

Purpose: To determine the effect of a getter splash on tube insulation resistance and on the level of the total observed control grid current.

W-15-1 (contd.)

Results: Test data shows that the tube insulation resistance is somewhat greater with the unflashed getter. Total control grid current was comparable to regular tubes with flashed getters. The gain in the total grid current level, which should have been realized from improved insulation resistance, appears to have been offset by a somewhat higher gas current. A slight increase in the control grid current crossover voltage led to the conclusion that flashing the getter changes the work function of the tube elements.

W-15-2

Regular CK587 with the glass envelope crimped in on top of the mica spacer.

Purpose: Determine the effect of a very tight bulb to mount fit on vibration induced noise output, and changes in static characteristics after shock.

Results: A very tight bulb to mount fit eliminated the extremely high noise output spikes which are normally generated when the mount slaps against the bulb during vibration testing. However, the overall output level was slightly higher than regular tubes, having a firm fit between the glass envelope and mica bumper points. Static characteristics were slightly more uniform in tubes having the glass envelope crimped in against the top mica spacers. Processing: EES-1, EAS-1.

W-16

Regular CK587 with an additional mica between the getter and the rest of the mount to serve as a getter "splash shield".

** Purpose: Determine the effect of getter splash micas.

Results: When comparing these samples with standard production tubes, there was no observable change of insulation resistance or change in the level of the total control grid current or crossover point. Therefore, it may be concluded that during the flashing of barium getters, vaporized barium travels throughout the mount structure and deposits on the tube elements. These deposits may cause changes in element work functions, which in turn produce wide variations in tube characteristics. Processing: EES-1, EAS-1.

W-17 Regular CK587 with a flashless zirconium aluminum bulk getter.

** Purpose: To evaluate insulation resistance of tubes with flashless getters. To observe the effect on the control grid current and the crossover voltage. To observe the effect of high temperature thermal sterilization on tube characteristics with this construction.

Results: The insulation resistance was measurably higher and the total observed grid current was considerably lower than control tubes with barium flash type getters. Exposure to a 150° centigrade temperature for one hour resulted in a major reduction in tube characteristics for all samples tested.
Processing: EES-1, EAS-1.

W-18 Mock-up samples with four leads sealed in the flat press and one lead in the opposite end of the glass envelope, to duplicate double ended structures such as the CK5889 and QV269.

Purpose: To study the decay time of the dielectric absorption current with the control grid lead located at the opposite end of the glass envelope from the leads in the flat press. To evaluate the effect of an external silver guard electrode applied to the glass envelope.

Results: Data for this group indicated a somewhat faster decay of the dielectric absorption current, which also appears to be of lesser magnitude than with the control grid lead in the flat press. The external bulb shield appeared to have little effect on the decay time of the dielectric absorption current.

W-19 Regular CK587 with less mass on the top filament tab.

* Purpose: To determine the effect of reducing the mass of the filament tab in the finished tube.

Results: An extremely wide spread in static characteristics was noted, which appeared to be the result of differences in filament temperature from tube to tube. Most of the samples had a very low filament resonant frequency while some appeared to have more than one resonant frequency point. The output, measured while the filament was resonating, was not sinusoidal, denoting the presence of different harmonics.
Processing: EES-1, EAS-1.

W-20 Regular CK587 with more mass on the top filament tab to tensioning spring support.

* Purpose: To determine the effect of increasing the mass of the filament tab in the finished tube.

Result: Both static characteristics and filament resonant frequency results were much more uniform than those obtained in the previous test. The level of the filament resonant frequency was also higher than results noted in the previous tests. Processing: EES-1, EAS-1.

W-21 Preliminary samples of the CK587 with the control grid brought out at the opposite end from the glass press.

Purpose: To determine the feasibility of producing this structure.

Result: Although comparable to the regular CK587 in other respects, samples from this test appeared to have a somewhat lower dielectric absorption current. The developmental number QV269 was assigned to this type. Later commercial samples were designated CK590. Processing: EES-1, EAS-1.

W-22 Regular CK587, except that all parts except the filament are gold plated.

Purpose: To determine the change in tube characteristics caused by gold plated elements on total observed grid current.

Result: The static characteristics were reasonably uniform but considerably lower than tubes made with standard parts. The total grid current observed was very high, which appeared to be due to the diffusing of the gold over the mica insulators, thus increasing the leakage between tube elements. Processing: EES-1, EAS-1.

W-23 Regular CK587 construction - modified to bring the control grid out at the end of the glass envelope, opposite the flat press and having all the tube elements except the filament gold plated.

Purpose: The same as W-22 - with an additional study of the effect of the longer external leakage path to the control grid on dielectric absorption current.

Result: Same as W-22 - plus the results that the high leakage masked any effect that the longer external leakage paths may have had on the dielectric absorption current.
Processing: EES-1, EAS-1.

W-24 Repeat of Test W-13 with mounts sealed in longer bulbs.

Purpose: This was an attempt to increase the distance separating the mount containing a gold plated control grid from the heat and possible contamination of the sealing-in fires.

Result: There was no apparent advantage gained from the use of a longer glass envelope.
Processing: EES-1, EAS-1.

W-25 Repeat of Test W14 with mounts sealed in longer bulbs.

Purpose: This was an attempt to evaluate an increase in the distance separating the mount containing a platinum plated control grid from the heat and possible contamination due to the sealing-in fires.

Result: There was no apparent advantage in using a longer glass envelope.
Processing: EES-1, EAS-1.

W-26 CK5886 mounts with the filament supported at the ends only; not touching mica spacers as is the case in regular production tubes.

* Purpose: To determine the total control grid current level and crossover voltage for this type of construction and to compare these with regular production tubes.

W-26 (contd.)

Result: Filament resonant frequencies for these tubes center around 3 KC which is about 20% lower than regular production tubes. There was no appreciable change in control grid current level or crossover voltage from the values observed for standard tubes.
Processing: EES-3, EAS-2.

W-27

Regular CK587 mount surrounded by an external metal shield, with the entire assembly sealed in a .690" diameter glass envelope.

Purpose: To determine the effect on all tube characteristics of a metal shield enclosing the mount structure. To study the level of total control grid current and the turn-on stabilization time.

Result: Characteristic data was completed and the results were comparable to the regular CK587. The grid current crossover voltage was about -1.8 volts and the turn-on stabilization time was equivalent to that of the regular CK587. Samples were forwarded to G.S.F.C. for further evaluation.
Processing: EES-4, EAS-1.

W-28

Regular CK587 with tungsten-rhenium filament wire and heavier than normal filament tensioning springs.

Purpose: To determine the effect of heavier than normal filament tensioning springs on tube stability and filament resonant frequency. Also to evaluate the effect on filament emission of 3% rhenium in the tungsten filament wire.

Result: The tungsten-rhenium wire and heavier filament spring have little effect on characteristic variations between tubes in the same lot. However, for any given tube, they appear to decrease the magnitude of the changes from the original characteristic values, which normally take place during environmental testing. The filament resonant frequency was raised slightly to about 9 KC. The addition of 3% rhenium in the tungsten filament wire lowered tube characteristic levels slightly, but this was corrected by the use of a different filament coating, identified as Raytheon formula 33-c-334.
Processing: EES-1, EAS-3.

W-29 Regular CK587 with the filament supported at the ends only, and positioned so as not to touch the mica spacers.

* Purpose: The same as Test W-26.

Results: The same as Test W-26.
Processing: EES-1, EAS-3.

W-30 Regular QV269 (standard CK587 mount with the control grid lead brought out at the opposite end from the flat press)... with an external silver envelope shield terminated in a ground lead in the flat press.

Purpose: To evaluate the effect of an external envelope shield on the control grid current. To determine if this external shield, when interposed between the control grid and other element connections, has any effect on the dielectric absorption amplitude and duration.

Results: After applying the external envelope shield, it was necessary to chemically clean and thoroughly wash both the press and tip of the tube before electrical evaluation. There was no apparent difference in the duration and amplitude of the dielectric absorption, nor in the level of the total control grid current from that of the standard QV269.
Processing: EES-1, EAS-3.

W-31 Tubes were obtained from several domestic and foreign manufacturers and measured for operating characteristics at Raytheon. Samples and data were forwarded to G.S.F.C. for initial current velocity tests.

Purpose: To evaluate reverse control grid current flowing at various bias voltages applied to the control grid. This test was aimed at a correlation of observed levels of control grid current to the initial velocity current in many tubes of different design and construction.

Result: Preliminary results from G.S.F.C. did show a correlation between control grid current and initial velocity current. Specifically, tubes with high initial velocity currents at -2.0 volts control grid bias also had high control grid currents.

W-32 Preliminary samples of the QV290 (regular CK587 parts assembled in a round mica for sealing in T3 bulbs).

Purpose: To evaluate the feasibility of constructing this type of mount, and to study the possible advantages of roll crimping the glass envelope against the top mica spacer.

Results: Mechanically the construction is feasible, but shock and vibration characteristics have not been determined because of difficulties encountered electrically. Unknown variables apparently exist during the processing cycle which prevent the production of uniform samples for environmental testing.
Processing: EES-1, EAS-4.

W-33 Regular CK587 with uncoated tungsten filament wire.

Purpose: To test the possibility of a very small tube with low voltages as an ionization guage.

Results: Tubes were fabricated and delivered to G.S.F.C. for evaluation. Processing: EES-1, NONE.

W-34 Regular CK587 complete tubes with envelope sealed in an external T5 1/2 envelope fitted with an exhaust tubulation.

Purpose: To test the effect of helium permeating the CK587 glass envelope and entering the tube vacuum.

Results: Samples were assembled and forwarded to the Technical Officer at G.S.F.C. for his evaluation.
Processing: EES-1, EAS-3.

W-35 Regular CK587 with grid numbers one and two omitted.

Purpose: To study the temperature gradient along the filament by the use of infrared radiometers and infrared photographs.

Results: Preliminary results obtained at Raytheon with an infrared radiometer were comparative only, as the .001" diameter filament wire did not fill the .060" diameter reticle. However, these readings were very valuable, as they did point out the variations which occur along the filament wire and from tube to tube. These samples were then delivered to G.S.F.C. for further studies. Processing: EES-1, NONE.

W-36 This test number was used to identify a separate order for 100 QV269 tubes, which were delivered to G.S.F.C.
Processing: EES-1, EAS-3.

W-37 Regular CK5886 mount, except that the oxide coated tungsten filament was replaced with an oxide coated nickel filament.

Purpose: Determine the effect of oxide coated nickel filament core metal on control grid crossover voltage.

Result: The helical tungsten filament tensioning spring normally used for the CK5886 construction exerted too much force on the nickel filaments, causing them all to break during processing. No further work was attempted on this approach.
Processing: EES-2, EAS-5.

W-38 Regular CK5886, except for the use of a flashless bulk getter.

Purpose: To determine the effect of flashless getters on the following parameters: control grid current; 1/F noise spectrum; control grid current crossover voltage; and control grid insulation resistance.

Results: To investigate the 1/F noise spectrum, spot quiescent noise readings were obtained at 10 cycles and 1000 cycles. The tubes having flashless getters appeared to be the same for this parameter as the control tubes. The control grid current was only slightly better than the grid current of the standard tubes but the grid current crossover voltage was shifted from the normal 1.6-1.8 volts to 1.8-1.9 volts. The insulation resistance was slightly better than for standard tubes, being in all cases greater than 2.0×10^{15} ohms.
Processing: EES-3, EAS-2.

W-39 Nippon Electric, type 5886 samples, measured for characteristics by Raytheon and returned to G.S.F.C. as part of the initial velocity current test series noted under W-31.

W-40 Regular CK587, except for a double carbonate filament coating containing 96% strontium carbonate and 4% calcium carbonate.

Purpose: To determine the effect of eliminating metallic barium from the tube structure. To study the specific effect on tube characteristics, total observed grid current level, control grid current crossover point, and long term drift.

Result: Many tube processing schedules were evaluated, but without barium in the coating; the tube characteristics obtained were much lower than standard CK587 samples. The total control grid current level was extremely low, (less than 1.0×10^{-15} amperes) probably due in part to the low tube characteristic level. The crossover point was about -1.6 volts, which is only slightly less than regular CK587 samples. Because of the low characteristic level, samples were not evaluated for long term drift. Processing: EES-1, EAS-6.

W-41 Regular CK587, with a baked on General Electric "Dri-Film" silicone water repellent layer applied to the bulb.

Purpose: To evaluate a more durable water repellent surface treatment, and its effects on total observed control grid current. Also, to determine its electrostatic charge retention properties.

Results: The grid current level and control grid insulation resistance were equivalent to values obtained for tubes having clean, uncoated glass envelopes. The electrostatic charge retention properties of bulbs having baked on General Electric "Dri-Film" were better than those obtained with other chlorosilicone coatings, but showed no improvement when compared to clean untreated glass envelopes. This approach was not pursued further since it showed no advantage over a clean glass bulb. Processing: EES-1, EAS-6

W-42 Regular CK587 with the glass envelope drawn in against both top and bottom mica spacers prior to exhaust.

Purpose: To evaluate the vibration induced noise response of tubes with very tight envelope to mica spacer fit.

Results: The vibration induced noise level was higher for the test than for the control. Melting the glass in against the top and bottom micas apparently locks the bulb tightly to the mount, transmitting a greater level of vibration to the individual tube element than occurs when the tube structure makes use of resilient mica bumper points only to anchor the mount.
Processing: EES-1, EAS-6.

W-43 Regular CK587 without "Hot Shot" during filament activation process.

** Purpose: To determine the effects of the so called "Hot Shot" during filament activation. The "Hot Shot" is a type of filament activation process in which an AC voltage of approximately four (4) times the normal operating filament voltage is applied for a few seconds to several minutes depending on the tube type.

This is used to convert the carbonates in the filament coating to oxides and perhaps produce a small quantity of free barium metal. During this processing step, a small amount of barium metal is vaporized onto the tube elements, changing their work functions in an erratic manner. Processing is possible without the "Hot Shot", but does require considerable time and additional effort.

Results: Tube characteristics were the same as those of the control tubes. The total observed control grid current and cross-over voltage were comparable to regular CK587 samples. However, after thermal sterilization, the characteristics of these tubes were changed less than the characteristics of any other filamentary tubes produced during the contract.
Processing: EES-1, EAS-7.

W-44 Regular CK587, except the entire getter assembly was left out and the tubes were processed at lower than normal temperatures.

** Purpose: To determine the effect on control grid current, control grid current crossover point, and control grid insulation resistance.

Results: The control grid current crossover point remained the same as the control, but the total grid current level was much higher than normal due to the high gas content. After subjecting the tubes to 150° centigrade for 100 hours the tubes were dead; that is, practically no emission current could be obtained from the filament. It is evident that some form of getter is necessary in glass envelope tubes to maintain adequate gas clean-up after seal-off. Processing: EES-1, EAS-7

W-45
W-46
W-47 This group of tests were designed to gather information on an experimental inverted triode. These tests were cancelled when samples of German inverted triodes, DC760 and DC762, were received.

W-48 Regular CK587 in Corning 0120 glass envelopes. Prior to use in final assemblies, envelopes were baked for sixteen hours at 400° centigrade and given a post bake wash in a 4% KOH solution.

** Purpose: To determine if a sixteen hour, 400° centigrade bulb bake with a post bake wash in KOH did, in fact, remove contaminants from the glass envelopes which poisoned cathode emission during 150° centigrade, 150 hour sterilization tests.

Results: Total control grid current and characteristic levels were very good prior to thermal sterilization. After sterilization in the tube, characteristics and control grid current showed some deterioration, but did not fall as markedly as in the case with the regular product.
Processing: EES-1, EAS-8

W-49 Regular CK5886 mount with the top filament support strengthened.

Purpose: This was an attempt to reduce the amplitude of the filament resonances in the CK5886 structure.

Results: Visual observation of the filament and filament support while the structure was being vibrated, indicated that the amplitude of the filament resonances were practically unchanged by this type of strengthening of the filament support.
Processing: EES-3, EAS-2

W-50 Regular CK587 with RCA triple carbonate filament coating Raytheon formula 33-C-334 on tungsten-rhenium filament wire.

Purpose: To determine emission level and stability of the RCA coating on tungsten-rhenium filament wire. To investigate the ability of tubes containing this type of filament to withstand thermal sterilization.

Results: Emission level of tubes containing these filaments was adequate. Higher than usual grid current readings for some of these tubes appeared to be due to leakage from other causes, which were not determined. Tubes from this test could not withstand thermal sterilization, with almost complete loss of emission caused by the high temperature storage.
Processing: EES-1, EAS-8.

W-51 CK587 mount with the control grid replaced by an open frame type grid having an aperture (.025" x .160") in each face plate rather than the conventional grid wire laterals.

** Purpose: To determine if a single aperture in each grid face plate, with dimensions designed to approximate the turn to turn spacing of the regular wound grid for this type, would provide a structure that might function as a control grid.

Results: Tube characteristics were comparable to those of the regular CK587 with a conventional wound grid. Vibration induced microphonic output did not appear significantly better for this structure when compared with standard tubes.

W-51 (contd.)

However, the total control grid current level was significantly improved, and the high grid current spikes which are normally associated with turn-on were eliminated - making possible much faster stabilization when a tube is first placed in operation. It should be noted that this type of grid shifted the grid current crossover point to a higher voltage in the order of -2.0 volts. Processing: EES-1, EAS-8

W-52

This test number was assigned to all data taken by Machlett Laboratories on the studies of residual gas in subminiature electrometer tubes.

Purpose: To determine if any contaminants, other than the well known gases, were contributing to failure of emission of electrometer tubes in the 150^{o} centigrade, 150 hour sterilization tests.

Results: No new information was gained by this test. It confirmed that which was already known.

W-53

Regular CK587 mounts, except platinum - 10% iridium oxide coated cathodes.

Purpose: To compare emission level and stability of platinum-iridium filaments. Determine if there is any significant change in the level of the observed grid current or its crossover point.

Results: Although the helical filament tensioning spring turned out to be an unsatisfactory type of spring for use with this relatively weak filament, the following results were obtained before all the filaments broke during the processing cycle.

The filament current for the .0009" diameter platinum-iridium filament in the CK587 is approximately 40 milliampers compared to 10 ma for the normal tungsten filament. The grid current level is apparently less than 2.0×10^{-15} amperes and the crossover point is approximately -2.1 volts bias. Due to the fragility of this filament system, this approach was not pursued further. Processing: EES-5, EAS-9

W-54 CK587 mounts having regular tungsten filament wire with heavier than normal weight triple carbonate coating.

Purpose: To determine the effect of an increased weight on the characteristics and grid current levels of the tube.

Results: Tube characteristic levels were low and the control grid current level was relatively high for most of the samples from this test. However, several samples that had good characteristics and a low level of grid current were subjected to thermal sterilization. None of the samples survived. Processing: EES-1, EAS-8

W-55 Regular CK587 mounts, except that the filament coating contains 50% calcium and 50% barium.

Purpose: In the standard triple carbonate coating, barium is evaporated preferentially during tube life, changing the work function of the filamentary cathode. The work function of the barium-calcium system changes by a very small amount for a very large change in the ratio of barium to calcium. Therefore, if adequate emission can be obtained from this coating, a reduction in overall long term drift should result.

Result: Tube characteristics were at a low level, but comparable with tubes in the control test W-60. The good tubes produced were exposed to thermal sterilization and did not survive the 150° centigrade temperature. Due to this failure and the low characteristic level of the remaining samples in the test, drift measurements were not obtained. Processing: EES-1, EAS-8.

W-56 Regular CK587, except filaments were coated with barium-strontium carbonates.

Purpose: To determine long term drift characteristic, emission level, and effect on control grid current and crossover voltage.

W-56 (cont'd) Results: The emission and control grid current levels were quite low, but comparable to the control test W-60, The control grid current crossover voltages was the same as that of the regular CK587 (approximately -1.8 volts bias). Long term drift was not evaluated due to the poor characteristic levels obtained in the test. Processing: EES-1, EAS-8

W-57 This was a 100 tube lot of type QV290, essentially the CK587 parts assembled in a new mica for use in the T-3 round bulb.

Purpose: To evaluate the CK587 tube design in a T-3 bulb which, hopefully, would be less microphonic than the regular CK587 in a T-1 1/2 x 2 bulb.

Results: The glass envelope can be softened and rolled in against the top mica without mechanical difficulties. However, as pointed out in test W-32, apparently there are unknown variables which exist in the processing cycle - preventing the production of good samples using this type of construction.
Processing: EES-1, EAS-8.

W-58 Large area triple carbonate, indirectly heated cathodes, sealed in the 0120 glass envelopes used for tube type CK587.

Purpose: To provide large area infrared sources for infrared radiometer and infrared film calibration. These sources are to be used as comparisons to standard electrometer tube filaments

Results: Tubes were forwarded to G.S.F.C.
Processing: EES-6, NONE.

W-59 Regular production CK5886, except a baked-on silicone water repellent treatment prior to final exhaust.

Purpose: To compare this treatment with the regular reactive type silicone water repellent treatment.

Results: This was a repeat of test W-42, except that the tube type CK5886 was used as the test vehicle rather than tube type CK587. The control grid current level, control grid insulation resistance, and charge retention properties were all good. Samples were forwarded to G.S.F.C. Processing: EES-3, EAS-2.

W-60 A regular lot of CK587 tubes mounted and processed at the same time as tests W-50, W-54, W-55, and W-56.

Purpose: To be used as a control on the above noted tests.
Processing: EES-1, EAS-8

W-61 Regular CK587, except the number one grid is of the wound frame type construction.

Purpose: To determine if the frame type construction will result in better lot uniformity of tubes.

Results: Tubes have been tested for GM, plate and screen currents, and they show a distribution of characteristics nearly the same as with regular production type wound grids. This seems to indicate that the low T.P.I. control grid does not have as much to do with the characteristic distribution as does the screen grid.
Processing: EES-1, EES-3, EAS-8

W-62 All data taken on several DC-760 and DC-762 German inverted triode electrometer tubes was collected under this test number.

Purpose: To bring together sufficient data from the analysis of the DC-760 and DC-762 to permit the manufacture of similar samples on this program.

W-63 Data taken on 200 CK587 tubes used in preparing the G.S.F.C. high reliability specification for electrometer tubes. Tubes
* which conform to this specification carry type number 8520.

Processing: EES-7, EAS-8

W-64 QV290 mount with Coors ceramic spacers in T-3 glass bulbs, using SAES, 80% zirconium - 20% aluminum flashless bulk getters.

** Purpose: To obtain samples of this construction for 150° centigrade sterilization evaluation.

W-64 (cont'd)

Results: Although characteristic levels were only about one half that of regular CK587 tubes, due probably to cooling of the filament by the ceramic spacers, it was possible to obtain control grid current curves before and after thermal sterilization. After thermal sterilization, leakage level improved noticeably. The control grid crossover voltage remained virtually unchanged.
Processing: EES-1, EAS-8

W-65

QV290 mounts with mica spacers in metal envelopes with ceramic headers.

Purpose: To obtain samples of this construction for 150^{O} centigrade sterilization evaluation.

Results: Purchased ceramic headers were not leak tight; therefore the test was abandoned.

W-66

QV290 mounts with ceramic spacers in metal envelopes with ceramic headers.

Purpose: To obtain tube samples using all metal and ceramic parts for thermal sterilization tests.

Results: Abandoned for the same reason as W-65.

W-67

Preliminary samples of tube type QV291 - an all-metal ceramic electrometer tube.

* Purpose: To design, construct, and evaluate an electrometer tube without mica spacers or external glass envelope.

Results: A method has been devised to allow the tube elements to be brazed to the top internal ceramic spacer without filament contamination; the design for this structure is complete. A leak tight metal-ceramic header containing seven flexible nickel leads has been produced. This header has been evaluated for resistance between leads, before and after exposure to ambient temperatures up to 500^{O} centigrade, with satisfactory results. Complete preliminary samples without getters have been produced with all mechanical construction problems overcome. There is still much to be done to provide an improved vacuum within the finished tube as well as better electrical characteristics.
Processing: EES-9, EAS-14

W-68 Preliminary samples of tube type QV292.

Purpose: To design, construct, and evaluate a true pentode space charge grid electrometer tube in a T3 glass envelope.

Results: The design of this experimental tube type is complete. First samples have been produced and evaluated while operating with many different test voltages applied. It is felt that this type of space charge electrometer tube could be used in a balance pair arrangement where the plate current of one tube is balanced with another tube by controlling the voltages applied to the #3 grids. However, unless some application is found for this or a similar type of tube which requires more definite parameters, further work probably should not be attempted.
Processing: EES-1, EAS-6.

W-69 QV290 mounts constructed with half grids and having the plate halves brought out separately.

Purpose: To provide a purely experimental structure, having two definitely different sides, but both depending on the same filamentary cathode for the emission of electrons. One side was to be regular with a #1 and #2 grid and the other side was to have the lateral turns of the #1 and #2 grid removed. This structure would make it possible to study more completely such phenomena as initial velocity currents.

Results: Samples were processed and forwarded to G.S.F.C. for evaluation.
Processing: EES-1, EAS-6

W-70 Regular CK587, except use .035" - .037" O.D. screen grid in place of the regular .038" - .040" O.D. screen grid.

Purpose: Determine effect on characteristic levels of a controlled change in the screen grid O.D.

Result: A considerably higher characteristic level was noted for the change in the screen grid O.D. This demonstrates the importance of the screen grid in controlling electrometer tube characteristics. Processing: EES-1, EAS-8

W-71 CK587 with a wound #3 suppressor grid in a T3 glass envelope.

Purpose: To evaluate a structure in which the filament and the suppressor grid form entirely separate circuits.

Results: Basic characteristics were the same as the regular CK587. The grid current level was very good with a crossover voltage of about -1.8 volts bias. Stabilization time was not improved and like the CK587, these tubes could not withstand thermal sterilization. Samples were forwarded to G.S.F.C.
Processing: EES-1, EAS-8

W-72 Regular CK587, except filament shortened and nickel filament tabs positioned against the mica top and bottom.

Purpose: To determine the effect of eliminating contact between the filament wire and the mica spacers. Specifically, to determine how this type of construction effects characteristic spread for a given sample - on/off characteristic repeatability and filament resonance.

Results: When comparing the characteristic levels of tubes within this test, a wide spread was still noted between the values for individual tubes. The filaments exhibited many harmonics with a resonant frequency slightly lower than that observed for regular samples of tube type CK587.

Individual tubes from this test exhibited large changes in characteristics when tapped while in operation, as opposed to veryminor changes for control tubes which were treated in the same manner. This construction thus appears to be inferior to the regular product.
Processing: EES-1, EAS-8

W-73 Regular CK587 assembled in a T3 glass envelope. Envelope to be coated internally with a metallic film which, in turn, is grounded through an external lead.

Purpose: To investigate the effect of internal bulb charge on tube performance

Result: Not completed. The test was by-passed in favor of other more important tests.

W-74 Regular CK587, except use special U-Bar for filament spring support.

Purpose: This was an attempt to procure a U-Bar which would position the filament spring so that the spring arm could be assembled to the filament tab, using a jig designed to provide the same tension on all the filaments of any given sample.

Results: U-Bars were designed and samples obtained but this approach was unsuccessful. The displaced metal used for a spring stop could not be controlled adequately and the spring became bound, causing a great variation in filament tension between tubes.

W-75 QV292 samples as in W-68 except plate halves were located approximately .030" closer to the filamentary cathode.

* Purpose: To provide a space charge grid pentode with a higher characteristic level than the preliminary samples produced in Test W-68.

Results: The plate and GM_1 levels were considerably higher for these tubes compared to tubes from Test W-68. The grid current level for this test remained as good as the satisfactory level experienced with the preliminary samples of Test W-68.
Processing: EES-1, EAS-6.

W-76 Preliminary samples of experimental type QV293.

* Purpose: To design and produce physical samples similar to the German inverted triode DC760. To evaluate these samples and, if possible, make the necessary changes in order to obtain equivalent electrical characteristics.

Results: The design is complete and physical samples were produced. The characteristic level is somewhat lower than the German prototype; but it is felt that a slight increase in the diameter of the control element will correct this.
Processing: EES-10, EAS-10

W-77 Preliminary samples of experimental type QV309, which is designed to be similar to the German inverted triode DC762.

* Purpose: The same as Test W-76.

Results: The same as Test W-76.
Processing: EES-10, EAS-11.

W-78 Repeat of Test W-51. CK587 mounts with the control grids replaced by an open frame type grid having a narrow aperture (.025"x .160") in each face plate rather than the conventional grid wire laterals.

Purpose: This was an attempt to repeat the results obtained in Test W-51 and provide additional samples for experimental testing.

Results: Although some samples were obtained with good characteristics it was felt that the rest of the samples produced became contaminated during processing, reducing the characteristic level. Good tubes which were evaluated for grid current level and cross-over point produced results which were identical with those obtained in Test W-51. Processing: EES-1, EAS-8.

W-79 The same as the previous test, except aperture size was reduced from .025" x .160" to .015" x .160".

Purpose: To evaluate an open frame grid which might be expected to have more control of the electron flow from the filament to the plate.

Results: Very poor. The narrow aperture so nearly cut the plate current off that a satisfactory set of voltages for operation could not be found. Processing: EES-1, EAS-8.

W-80 Regular CK587 with the same type of open frame control grid, but with the aperture size increased to .035" x .160".

* Purpose: To evaluate the effect of a larger aperture on tube characteristics and behavior.

Results: The larger aperture was responsible for a much higher characteristic level while maintaining all the good features of previous experiments. The total control grid current level was very low combined with quick stabilization through the elimination of high grid current peaks at turn-on. Processing: EES-1, EAS-8.

W-81 Thermal sterilization data for the Victoreen 5800 and Mullard ME 1403 was collected under this number.

Purpose: To have the thermal sterilization data for these types readily available for comparison with similar data for tube types developed on the contract.

W-82 A special QV290 structure having a wound #3 grid and two filaments which could be operated individually.

Purpose: To determine the effect on characteristics and total observed control grid current of a structure having two filaments operating independently with applied filament potentials of reverse polarity.

Results: It was determined that with each change in the polarity of one filament voltage, with respect to the other, significant changes took place in the total observed control grid current and tube characteristics. Processing: EES-1, EAS-8.

W-83 QV291 mounts sealed in T3 glass envelopes.

Purpose: This was an attempt to produce QV291 samples in glass envelopes to evaluate processing techniques before using metal envelopes and ceramic headers in the final samples.

Results: Characteristic levels were low; apparently caused by excessive filament cooling by the ceramic spacers. These results prompted a later, more successful test (see W-105) in which the ceramic spacers were thinned to a few thousandths of an inch in the area where they make contact with the filament.
Processing: EES-1, EAS-8.

W-84 QV291 samples with the filament suspended so that it does not make contact with the ceramic spacers. The final assemblies were sealed in T3 glass envelopes.

Purpose: To evaluate samples without filament cooling from the ceramic spacers.

Results: The anticipated higher characteristic levels were not attained, indicating the harmful effect of variables other than the filament temperature. Processing: EES-1, EAS-8.

W-85 Regular QV290 samples.

Purpose: To evaluate the effect on tube characteristic levels of mount washing and rolling the glass envelope in against the top micas.

Results: The results obtained from the multivariable experiments seem to indicate that mount washing or bulb crimping, as such, are not the singular reasons for poor emission with this type of structure. An unknown variable may exist in the processing cycle used with this type of structure, that ultimately causes poor results in the finished product.
Processing: EES-1, EAS-8.

W-86 Preliminary samples of tube type QV331. A cathode electrometer tube similar to the 7851, but having an improved grid current level.

Purpose: To design and produce a cathode electrometer tube for use in applications in which conservation of heater power is not a prime requirement.

Results: The design work, an experimental parts list, and drawings were completed for this type. A seven pin single ended tube was produced with quite satisfactory results. Typical characteristics and operation include a triode amplification factor of 4, a plate current of 18 microamperes, a transconductance of 40 micro-mhos, and a grid current of less than 3.0×10^{-14} amperes. Processing: EES-8, EAS-13.

W-87 Regular CK587 samples with all the metal parts cleaned and fired under laboratory conditions. A new spool of tungsten wire was also etched and coated in the laboratory for this test.

Purpose: This was an attempt to isolate the possible cause or causes of low emission experienced during this period.

Results: After the tubes were sealed-in, the lot was split into two parts. One-half of the tubes were processed on the regular trolley, while the remaining half were processed on the Varian-Vac-Ion ultra high vacuum system. The results were the same for both exhaust systems. Characteristics for tubes throughout the entire lot were, on the whole, poor - with the wide range of values indicating that emission problems still existed.
Processing: EES-1, EAS-8.

W-88 Regular CK5886, except open frame type of control grid. Aperture size: .035" x .320".

* Purpose: To evaluate the open frame type of control grid in a type
** other than the CK587.

Results: This test confirmed the results obtained with this type of control grid in the CK587. See Test W-80. Higher pentode plate and screen currents, as well as higher transconductance results, were obtained. As noted with the CK587, the grid current level in the CK5886 was considerably lower than for prototypes with wound control grids. Due to the elimination of high grid current peaks at turn-on, stabilization time was also improved.
Processing: EES-3, EAS-2.

W-89 Type QV293 - an inverted triode with regular 77 T.P.I. anode, and the control element I.D. increased from .040" to .045".

Purpose: To raise the characteristic levels.

Results: Although slightly higher characteristic levels were obtained with this construction they were still not as high as desired. Results from this test indicate that another test should be run with an anode having a higher T.P.I., in addition to the larger I.D. control element tried in this test. See Test W-104.
Processing: EES-10, EAS-10.

W-90 Type QV292, a space charge grid pentode with a 62 T.P.I. control grid in place of the original 52 T.P.I. control grid.

Purpose: To raise characteristic levels.

Results: This attempt was unsuccessful. It is felt that problems associated with the processing of T3 electrometers effected the results of this test, but insufficient time was available to repeat the test before the end of the contract.
Processing: EES-1, EAS-10.

W-91 Regular CK587 samples assembled in the regular production mount area.

Purpose: To eliminate the clean air conditioned area as a possible source of contamination by assembling a test sample in the regular production area for evaluation and comparison with tubes made in the special area.

Results: The assembly area apparently had nothing to do with the poor results experienced with several previous tests; as the results of tubes made in both areas were equally poor.
Processing: EES-1, EAS-8.

W-92 Regular production CK587 samples.

Purpose: To investigate the effect on emission of prolonged storage between mount washing and final processing.

Results: Storage after washing apparently had little effect on the emission level. Tubes made in April, washed in May, and processed in November of 1965, were for the most part, very good tubes.
Processing: EES-1, EES-11, EAS-8.

W-93 CK587 - A controlled test on filament manufacture.

Purpose: The most delicate tube part operation, and the one with a number of possible variables, is the filament etching and coating process. To eliminate the filament made on current facilities as a possible source of low emission, filaments which were made on previous facilities and which produced good tubes were placed in current mounts and evaluated. This test did not show an improved characteristic level.
Processing: EES-1, EAS-8.

W-94 Type CK587, all parts made on current program facilities.

Purpose: Control for Test W-93.

Results: Both tests W-93 and W-94 had very low characteristic levels, as W-93 contained known good filament these tests seem to eliminate the filament as the variable causing low emission.
Processing: EES-1, EAS-8.

W-95 CK548 samples containing CK587 filaments. A CK548 is a regular production filamentary tube with a similar, but slightly longer construction than the CK587.

Purpose: To evaluate CK587 filaments in a similar tube type which was running well in regular production.

Results: The CK587 filament in the CK548 structure did produce good CK548 samples. The filament itself is apparently good.
Processing: EES-1, EAS-8.

W-96 Regular CK587 mounts containing CK548 filaments cut to length.

Purpose: This was another attempt to eliminate the filament as the cause of low emission in CK587 and QV290 tests.

Results: The CK548 filament did not make good CK587 tubes. This confirmed the results obtained in Tests W-93 and W-94. The filament does not appear to be the variable causing low emission problems in tube types CK587 and QV290.
Processing: EES-1, EAS-8.

W-97 CK587 mounts - assembled from parts that were cleaned under laboratory conditions and sealed in long glass envelopes.

Purpose: To assemble mounts from parts having a special cleaning, and to seal the units as far from the sealing-in fires as possible in order to avoid any chance of contamination from this source.

Results: This test did not provide an answer to the contamination problem. The results were very poor.
Processing: EES-1, EAS-8.

W-98 Regular CK587 units with the grids cleaned by an alternate method. Filament, spool #22-2-A.

Purpose: To evaluate a method of cleaning the grids, which does not involve production methods or equipment. To determine if contaminated grids contribute to poor characteristic levels.

Results: Although the characteristic levels for W-98 and W-99 were both low, the test having grids which were cleaned by an alternate method had a lower level than the test containing regular production cleaned grids.
Processing: EES-1, EAS-8.

W-99 Regular CK587 units with production cleaned grids and filament spool #22-2-A. Control for Test W-98.

Purpose: To compare grids cleaned by an alternate method with regular production cleaned grids.

Results: Although this control test did not provide an answer to the contamination problem, it did seem to indicate that the production method of cleaning the grids was superior to the alternate method tried.
Processing: EES-1, EAS-8.

W-100 Regular CK587 using filament spool #72-1-C which was processed on current facilities.

Purpose: To compare results obtained with a spool of filament wire processed on present facilities with one processed at a previous time. (See test W-101 for control.)

Results: The results of this test, and a repeat of this test two weeks later, were very good. Since both lots W-100 and W-101 were randomized and processed simultaneously, the conclusion can be drawn that some lots of filament wire are more susceptible than others to the processing variables affecting the emission level of the finished tube.
Processing: EES-1, EAS-8.

W-101 Regular CK587, using filament from spool #22-2-A which had been processed on previous facilities.

Purpose: This is the control for test W-100.

Results: Characteristic levels were not as satisfactory as those obtained in test W-100 which made use of filaments from spool #72-1-C. Processing: EES-1, EAS-8.

W-102 Regular samples of the cathode electrometer tube type QV331.

Purpose: To investigate the effect of lower cathode drain during the processing cycle.

Results: Characteristic and grid current levels were very good, and the tubes appeared to be slightly more stable than the preliminary samples. Processing: EES-8, EAS-13

W-103 QV290 samples (CK587 in a T3 bulb), assembled with filaments from the filament spool used successfully in test W-100.

Purpose: This was an attempt to produce good QV290 samples using filaments from a spool which produced good CK587 tubes. Samples were fabricated and finished with regular bulbs and with bulbs crimped in against the top mica spacer, to determine if the crimping operation might be an additional source of trouble in producing good QV290 samples.

Results: Characteristic levels for the uncrimped tubes were very good, but the levels for the crimped version were quite bad. It appears that the crimping operation, which adds a significant amount of heat to the bulb, introduces additional harmful effects. Processing: EES-1, EAS-8.

W-104 Inverted triode type QV293 samples with an 87 T.P.I. anode in place of the regular 77 T.P.I. anode. Samples were constructed with a rectangular control element of .045" I.D. and with an oval control element of .040" I.D.

Purpose: To investigate the effect of increasing the T.P.I. of the anode and using different diameter control elements on tube characteristic levels.

Results: Samples containing the higher T.P.I. of the anode and .045" I.D. rectangular control elements produced the most satisfactory inverted triodes produced during the contract. The results seem to indicate a further slight increase in the I.D. of the control element will produce the desired characteristic level.
Processing: EES-10, EAS-10.

W-105 QV291 samples in glass envelopes with the thickness of each ceramic spacer reduced to a few thousandths at the point of contact with the filament.

* Purpose: To obtain samples for comparison with complete metal-ceramic QV291 samples.

Results: Several good samples were obtained which could be used as control tubes for future metal-ceramic samples.
Processing: EES-1, EAS-8.

W-106 Regular QV331 samples with the cathode coating weight increased from .95 - .99 mgs to 1.15 - 1.25 mgs.

* Purpose: To raise the overall characteristics slightly.

**

Results: Tube characteristic levels were successfully raised to the values now appearing in the data sheet contained in this report.
Processing: EES-8, EAS-13.

W-107 QV290 samples for processing tests.

Purpose: Attempts, through processing variations, to produce good QV290 samples with the envelope glass softened and rolled in against the top mica spacers.

W-107 (cont'd)

Results: In spite of all efforts expended to date, there are still variables connected with this particular process which are not controlled. This test emphasized the fact that by taking all known precautions during fabrication and processing it is possible to produce good tubes in T3 bulbs without crimping on one day, but on another, the same precautions and set up may fail to produce a single good tube.
Processing: EES-1, EAS-8.

W-108

QV331 samples with the #2 stem pin welded to the bottom shield.

Purpose: To evaluate tubes having the #2 stem pin welded to the bottom shield for additional mechanical support.

Results: The structure was more rugged which was particularly valuable during insertion of the mounts into the bulbs. The characteristic levels were equivalent to tubes made without the #2 stem pin welded to the shield. These samples are available for evaluation in test equipment, but it must be remembered that the #2 lead is now at cathode potential, rather than floating as in previous samples.
Processing: EES-8, EAS-13

W-109

Regular CK587, except both the control and screen grid were of the open frame construction.

Purpose: To evaluate the open frame type of grid when used as a screen grid.

Results: The basic design employed, in which the screen grid aperture was larger than that of the control grid, appears to be undesirable. Future tests should investigate the possibility of using a screen grid with an aperture which is narrower than that of the control grid in order to increase the effectiveness of the accelerating field produced by this type of screen grid.
Processing: EES-7, EAS-8.

W-1 Preliminary samples of a shortened CK587 with filament drain reduced from 0.010 amperes to 0.005 amperes.

Purpose: To design, construct, and evaluate a shorter length low drain version of electrometer tube type CK587. This shortened version was assigned the experimental type number QV271.

Results: Feasibility of this design was demonstrated and samples were produced.
Processing: EES-12, EAS-15.

W-2 QV271 samples with 10 milliampere CK587 tungsten-rhenium filaments.

Purpose: To evaluate samples for characteristics and filament resonance with ten milliampere filament wire in the short QV271 structure.

Results: Characteristics and grid current were comparable to regular CK587 tubes. The filament current was approximately 11.5 ma and the filament resonance was raised from approximately 7500 Hertz for the regular CK587 to approximately 12000 Hertz for this version of the QV271.
Processing: EES-13, EAS-15.

W-3 QV271 samples with 5.0 milliampere tungsten-rhenium filaments.

Purpose: To evaluate QV271 samples with a stronger 5 milliampere filament material.

Results: Although there were quite a few samples with pentode characteristics comparable to the regular CK587, the overall level was on the low side. Subsequent tests with tungsten-rhenium wire in the CK587 indicated that a higher characteristic level could be expected using an improved filament coating.
Processing: EES-12, EAS-15.

APPENDIX III

SIGNIFICANT DATA AND GRAPHS FOR EXPERIMENTAL TESTS RUN DURING THE CONTRACT

APPENDIX III

SIGNIFICANT DATA & GRAPHS

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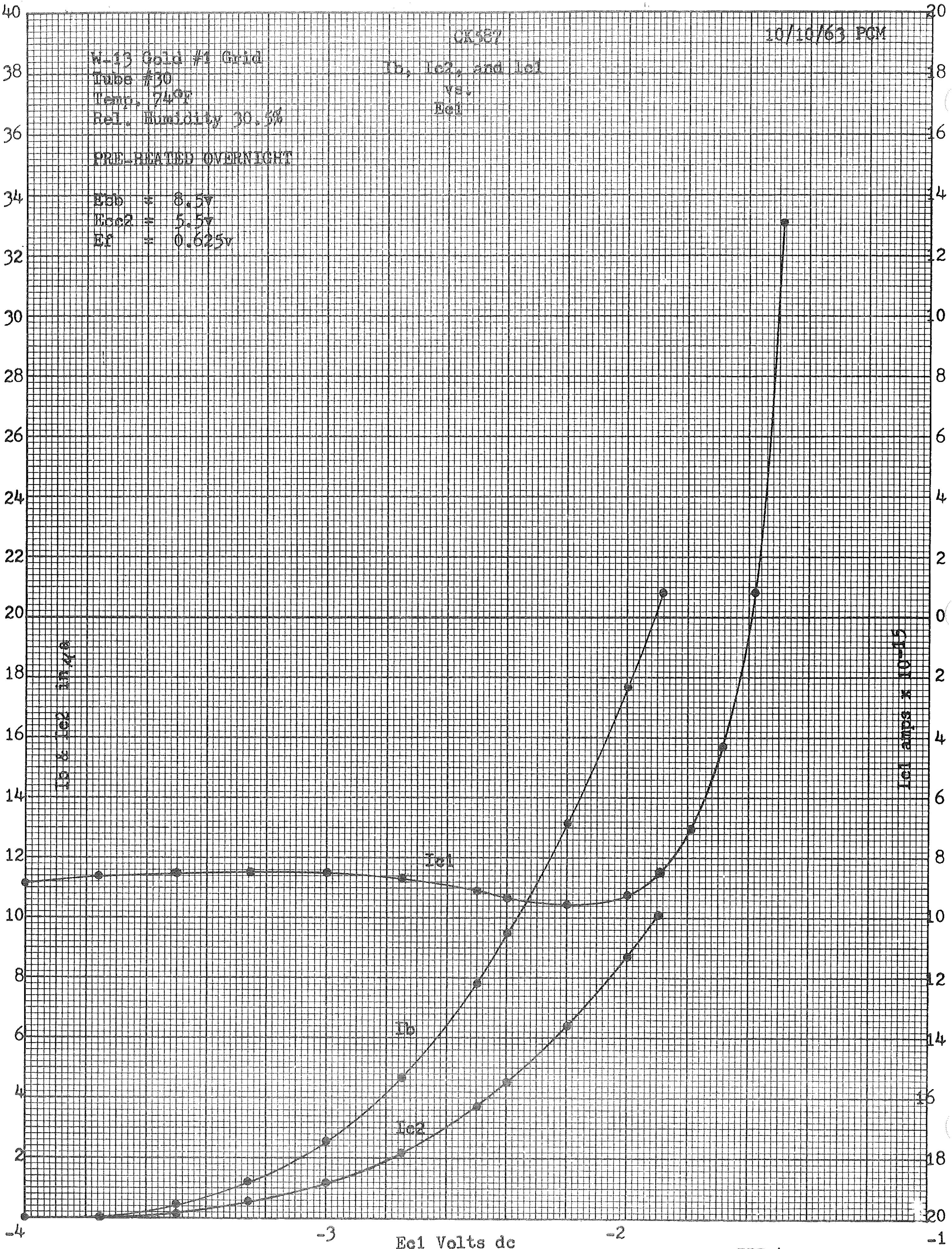
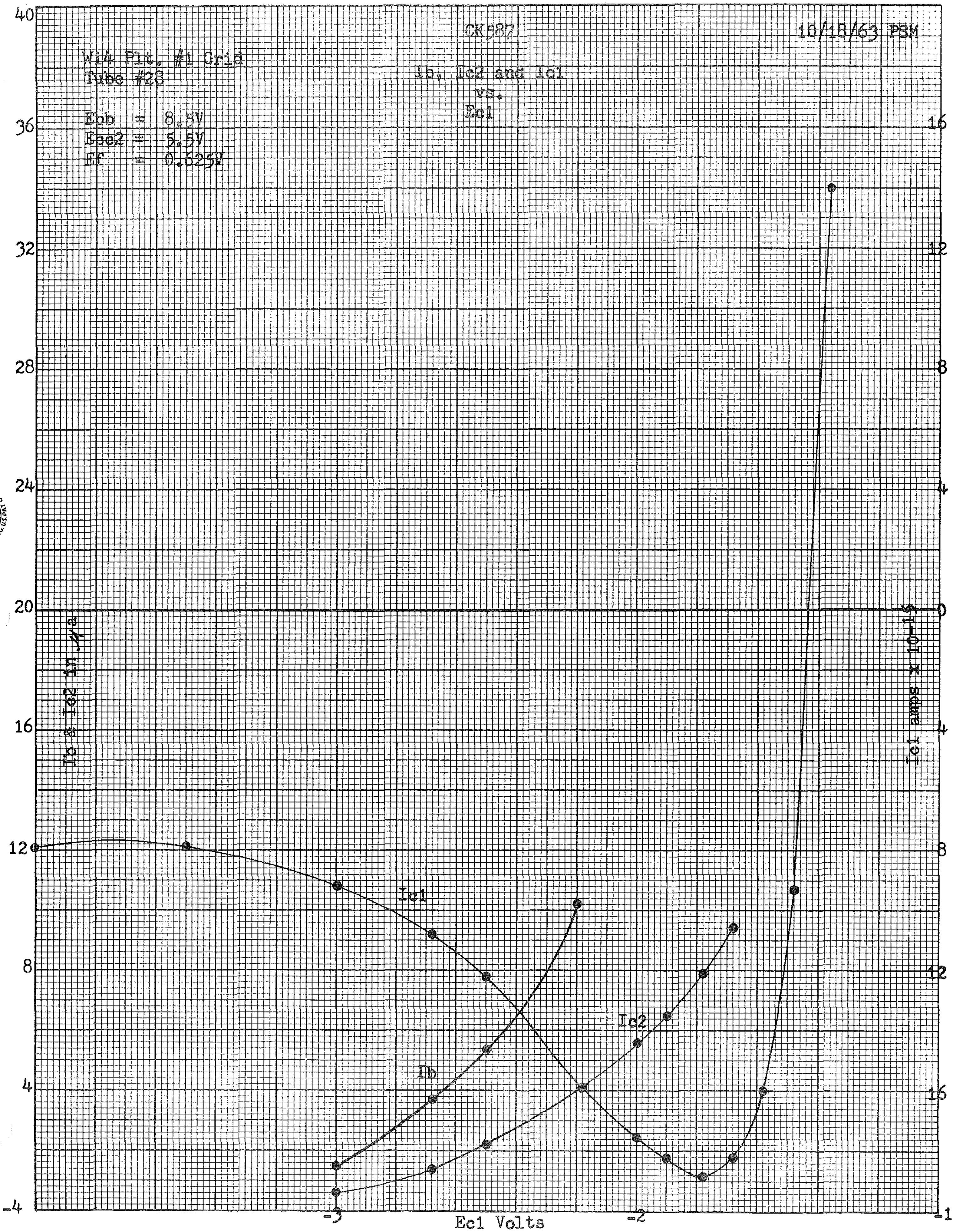
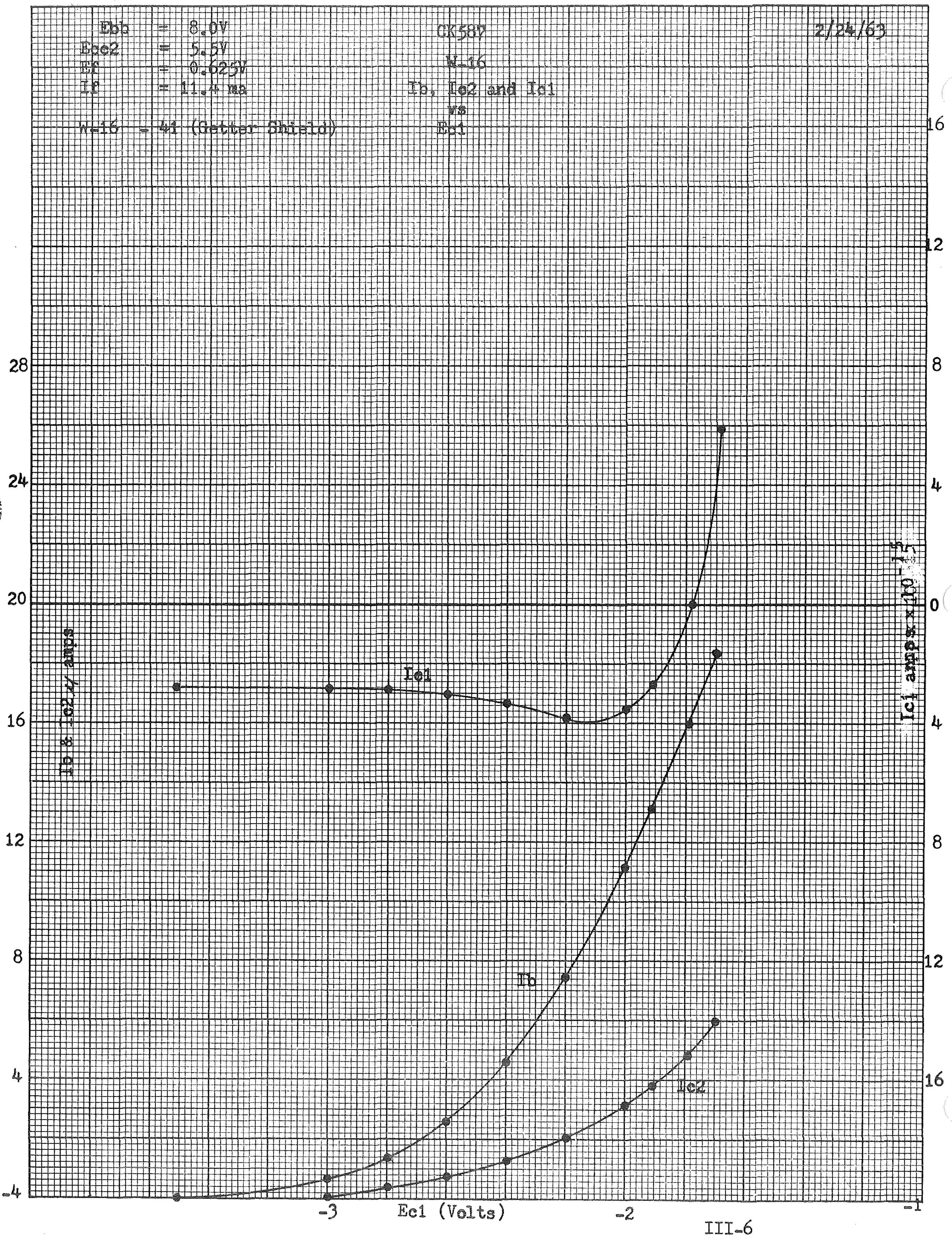
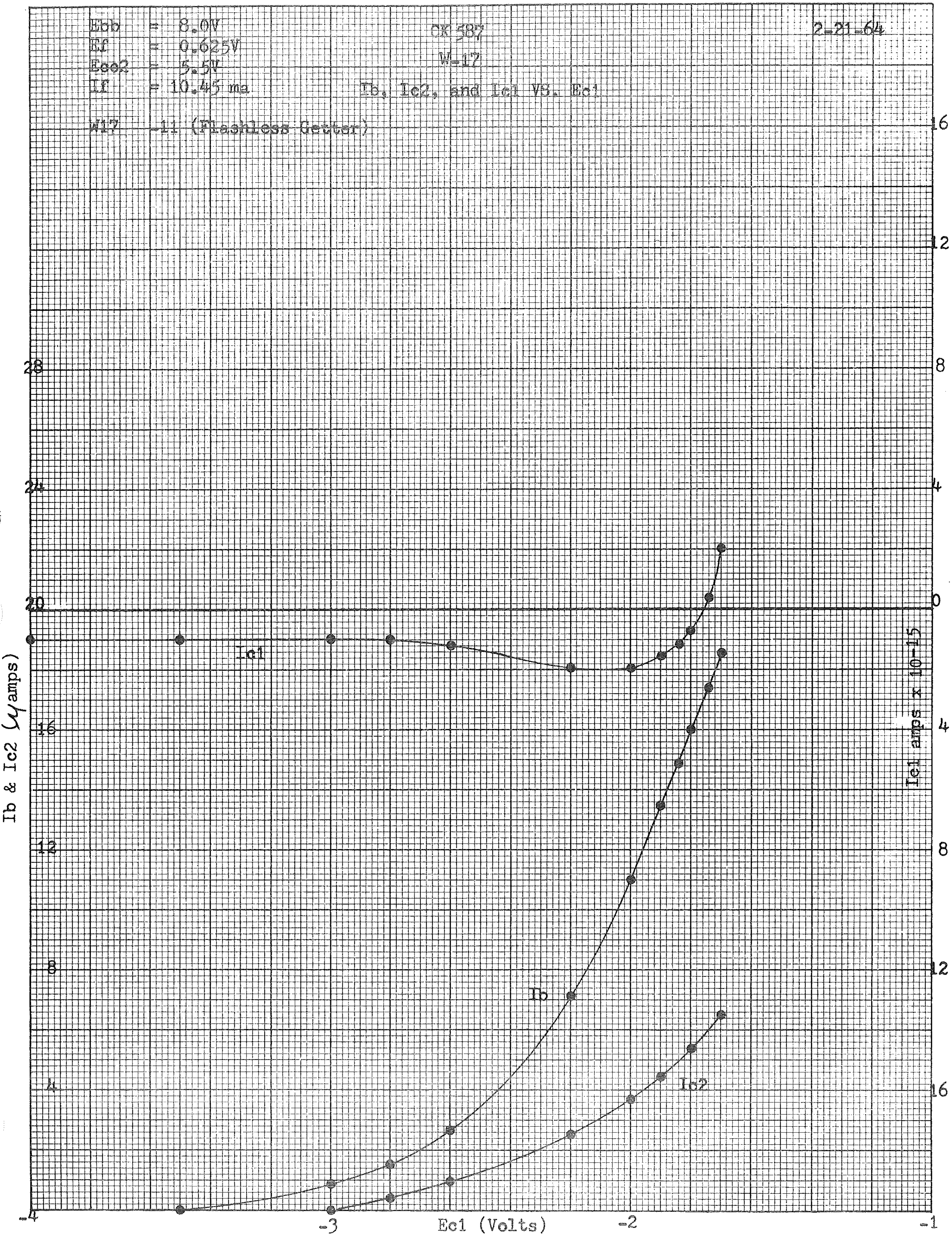
TABLE OF CONTENTS (CONTINUED)



W-13 Gold #1 Grid
Tube #30
Temp. 74°F
Rel. Humidity 30.5%
PRE-HEATED OVERNIGHT
Ebb = 8.5v
Ecc2 = 5.5v
Ef = 0.625v
CK587
Ib, Ic2, and Ic1
vs.
Ec1
10/10/63 PGM
Ib & Ic2 in μa
Ic1 amps x 10⁻¹⁵
Ic1
Ib
Ic2
Ec1 Volts dc
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
-4
-3
-2
-1


CK587
10/18/63 PSM
W14 Plt. #1 Grid
Tube #28
Ib, Ic2 and Ic1
vs.
Ec1
Ebb = 8.5V
Ecc2 = 5.5V
Ef = 0.625V
40
36
32
28
24
20
16
12
8
4
-4
16
12
8
4
0
4
8
12
16
1
Ib & Ic2 in μa
Ic1 amps x 10-15
Ic1
Ic2
Ib
-3
-2
-1
Ec1 Volts


Ebb = 8.0V
Ecc2 = 5.5V
Ef = 0.625V
If = 11.4 ma
W-16 = 41 (Getter Shield)
CK58V
W-16
Ib, Ic2 and Ic1
vs
Ec1
2/24/63
Ic1
Ib
Ic2
Ib & Ic2 μ amps
Ic1 amps x 10^-15
Ec1 (Volts)
28
24
20
16
12
8
4
-4
-3
-2
-1
16
12
8
4
0
4
8
12
16



Ebb = 8.0V
Ef = 0.625V
Ecc2 = 5.5V
If = 10.45 ma
W17 -11 (Flashless Getter)
CK 587
W-17
Ib, Ic2, and Ic1 VS. Ec1
2-21-64
Ib & Ic2 (μ amps)
Ic1 amps x 10-15
Ec1 (Volts)
Ic1
Ib
Ic2
28
24
20
16
12
8
4
-4
-3
-2
-1

TEST W-19 (REG. CK587 With Less Mass On Top Filament Tab)

Tube No.	I_b - μa	I_{c2} - μa	Gm1 - μmhos	Filament Resonance (KH_Z)
19- 1	44.0	23.2	30.5	4.30 (5.05 ?)
19- 2	9.7	3.2	19.8	8.50
19- 3	11.0	4.6	25.3	8.50
19- 6	11.0	4.4	26.2	7.80
19- 7	9.8	3.5	21.0	8.45
19- 8	10.0	5.4	20.0	8.75
19- 9	9.2	3.1	20.0	9.05
19-10	10.0	4.2	23.6	8.10
19-11	24.0	11.2	28.8	7.30
19-13	10.0	3.6	23.7	8.80
19-15	10.0	4.0	23.9	8.40
19-16	8.9	2.9	18.7	9.30
19-17	16.0	8.2	28.0	2.20 (5.10 ?)
19-19	10.0	2.8	22.0	7.10
19-20	10.0	3.4	22.3	8.00
19-21	10.0	4.3	23.4	9.40
19-22	28.0	12.2	31.3	8.10
19-23	13.0	4.8	27.7	7.60
19-24	20.0	11.2	26.3	9.20
19-25	10.0	2.8	22.8	6.80
19-26	38.0	13.2	30.2	2.97 (5.00 ?)
19-27	30.0	14.2	32.3	2.40 (9.60 ?)
19-29	8.7	3.3	19.0	8.20
19-30	9.8	3.1	21.0	8.40
19-31	10.0	4.0	23.0	8.65

TEST W-20 (Reg. CK587 With More Mass On The Top Filament Tab)

Tube No.	I_b - uA	I_{c2} - uA	GM_1 - u-mhos	Fil. Resonance (KH_z)
20-1	13.0	3.8	27.6	8.75
20-2	11.0	4.5	25.7	7.90
20-3	15.0	6.4	29.9	7.98
20-4	13.0	5.7	27.7	7.22
20-5	10.0	4.0	25.9	9.10
20-6	9.0	3.2	20.9	9.60
20-7	18.0	6.3	31.8	8.10
20-8	10.0	3.6	22.5	9.00
20-9	9.0	4.0	20.9	8.00
20-10	14.0	5.0	28.5	7.30
20-13	10.0	4.3	23.9	7.90
20-14	12.0	5.2	25.8	8.40
20-15	9.0	3.4	20.8	7.80
20-17	11.0	4.4	25.9	8.00
20-19	12.0	5.0	25.4	7.05
20-20	12.0	4.9	26.7	7.60
20-21	11.0	4.2	25.4	10.00
20-22	10.0	3.9	22.9	7.80
20-23	12.0	5.0	26.6	7.40
20-25	19.0	5.2	31.9	7.98
20-28	12.0	4.4	27.0	7.95
20-29	10.0	4.2	25.1	7.55
20-30	11.0	4.3	25.0	8.05
20-32	10.0	4.0	23.8	7.40

It should be noted that test W-19, which is a regular CK587 with less mass on the top filament tab, required a much stronger magnetic field to start it resonating than did the W-20. The output was not sinusoidal denoting the presence of different harmonics. In some instances tubes from test W-19 appeared to have more than one resonant frequency point.

TEST W-26

The CK5886 samples with the filaments suspended free of the micas gave the following results:

Test Conditions - Triode Connected

E_f = 1.25 V D.C.	Filament Resonance Test Only.
E_{c1} = 0	Triode conditions were the same except 100 μ volts A.C. (variable frequency) was superimposed on the D.C. filament voltage and the tubes were operated in a magnetic field
E_{bb} = E_{cc2} = 22.5V D.C.	
R_1 = 100 K Ohms	

Tube No.	I_f ma	I_b μa	I_{c1} Amps.	Filament Resonance (cycles)	
26-1	10.1	185	1.9×10^{-13}	3400	Without filament spring step on U Bar.
26-2	10.1	193	1.7×10^{-13}	3350	
26.3	10.1	194	1.3×10^{-13}	3350	
26-4	10.1	180	1.7×10^{-13}	3200	With filament spring stop on U Bar.
26-5	10.0	185	1.7×10^{-13}	2950	
26-6	10.2	190	1.5×10^{-13}	3200	

TEST N-29

CK587 (Filament Not Touching Micas)

Test Conditions:

E_{bb} = 8.0V
E_{cc} = 5.5V
E_f = 0.625V
E_{c1} = -2V Bias

Tube No.	I_f - ma	I_b - μA	I_{c2} - μA	$I_{c1} \times 10^{-15}$ Amp.
29-48	9.15	11.0	3.1	1.8
29-1	10.15	11.6	3.9	2.5
29-16	10.05	12.3	4.8	2.1
29-39	10.05	12.7	5.3	2.0
29-41	9.4	10.3	3.25	1.4
29-17	10.45	20.0	7.4	1.4
29-22	10.25	26.0	8.5	2.9
29-12	9.3	14.5	4.7	1.8
29-8	10.15	19.0	7.5	2.1
29-36	9.25	10.5	4.6	1.8
29-47	9.4	12.7	6.0	2.0
29-24	9.4	12.0	4.35	2.1

TEST W-38

CK5886 (Flashless Getters)

Tube No.	Noise Ref. Level (-131.5 db)	Noise Ref. Level (-160.5 db)
1	- 111.5 db	- 139.5 db
2	- 112.5	- 140.5
3	- 111.5	- 138.5
4	- 110.5	- 138.5
5	- 112.5	- 137.5
6	- 112.5	- 139.5
7	- 113.5	- 138.5
8	- 113.5	- 136.6
9	- 113.5	- 138.5
10	- 114.5	- 135.5
11	- 113.5	- 140.5
12	- 113.5	- 139.5
13	- 112.5	- 138.5
14	- 113.5	- 138.5
15	- 113.5	- 139.5
16	- 113.5	- 131.5
17	- 113.5	- 139.5
18	- 113.5	- 137.5
19	- 114.5	- 139.5
20	- 112.5	- 139.5
21	- 114.5	- 141.5
22	- 113.5	- 138.5
23	- 113.5	- 138.5
24	- 114.5	- 138.5
25	- 113.5	- 137.5
26	- 113.5	- 139.5
27	- 114.5	- 139.5
28	- 113.5	- 138.5

CK5886 - CONTROL PRODUCTION LOT #130

Tube No.	Noise Ref. Level (-131.5 db)	Noise Ref. Level (-160.5 db)
1	- 113.5 db	- 141.5 db
2	- 114.5	- 140.5
3	- 114.5	- 140.5
4	- 113.5	- 137.5
5	- 114.5	- 139.5
6	- 115.5	- 138.5
7	- 112.5	- 139.5
8	- 113.5	- 139.5
9	- 112.5	- 138.5
10	- 113.5	- 132.5
11	- 110.5	- 138.5
12	- 112.5	- 138.5
13	- 112.5	- 137.5
14	- 113.5	- 140.5
15	- 114.5	- 139.5
16	- 113.5	- 139.5
17	- 113.5	- 140.5
18	- 113.5	- 139.5
19	- 114.5	- 140.5
20	- 114.5	- 140.5
21	- 112.5	- 138.5
22	- 112.5	- 137.5
23	- 113.5	- 139.5
24	- 112.5	- 138.5
25	- 113.5	- 139.5
26	- 113.5	- 139.5
27	- 113.5	- 139.5
28	- 113.5	- 141.5

REGULAR CK5886

Test Conditions: The tube is operated so as to draw approximately 230 μa plate current. A meter, placed in the plate circuit, is balanced at 15 μa. Variations in plate current are read directly from this point after each tap or on-off cycle of the filament.

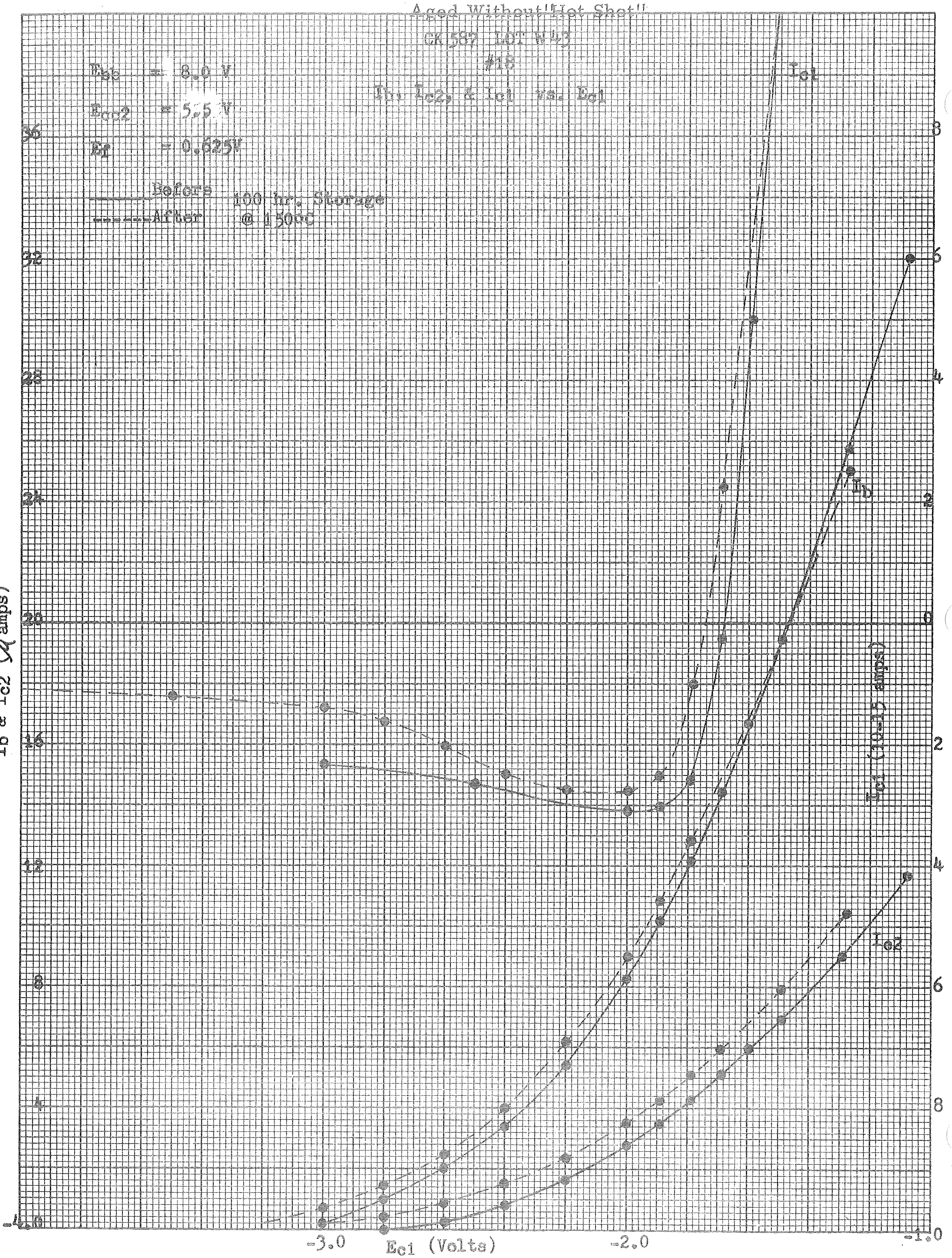
MECHANICAL TAP TEST

Tube No.	Direct Meter Readings/Cycle									
1	14.2	11.5	12.5	10.8	7.0	11.5	9.4	9.0	11.0	11.5
2	17.5	14.8	10.8	8.3	13.0	15.0	12.0	13.0	15.5	9.5
3	12.8	10.0	12.5	11.8	13.5	13.0	11.8	13.8	14.5	12.5
4	12.0	12.0	11.5	14.0	14.8	13.5	13.0	13.5	14.0	14.0
5	21.5	22.3	22.0	19.5	22.8	22.0	19.5	22.0	21.5	22.0
6	16.5	15.3	14.3	13.0	12.0	14.0	13.0	11.5	12.0	12.0
7	17.3	17.3	17.0	16.3	16.0	16.0	16.5	16.5	15.0	14.8
8	17.0	14.0	15.0	13.5	14.3	14.8	13.8	16.0	15.0	15.5
9	16.3	14.3	14.8	14.5	13.8	11.5	13.0	15.0	13.5	12.0
10	18.8	18.0	17.5	18.8	15.0	16.3	16.0	17.0	16.5	17.5
11	9.0	12.8	8.0	9.0	16.0	8.5	9.0	7.5	7.5	5.0
12	19.0	19.5	16.5	19.0	17.5	19.0	16.5	20.0	16.5	
13	21.5	20.0	19.0	22.0	24.0	21.5	19.5	18.5	18.0	20.5
14	20.5	20.0	18.0	18.0	16.0	17.5	18.0	18.0	15.0	15.8
15	15.5	15.5	15.3	15.0	14.5	15.0	12.0	11.0	11.5	10.0
16	18.0	17.5	16.5	17.0	17.0	16.0	15.3	18.0	17.3	16.3
17	19.5	18.8	18.0	17.5	17.5	15.5	19.0	12.0	16.5	16.0
18	18.0	15.5	13.5	12.0	13.0	13.0	12.0	10.0	11.5	12.5
19	15.8	14.8	16.0	15.5	16.3	15.8	14.5	13.0	12.5	12.5
20	19.8	12.0	15.0	24.0	20.5	20.0	19.5	15.0	19.8	19.5
21	18.0	17.5	17.8	17.0	18.5	16.3	18.8	16.5	18.5	18.5
22	14.0	10.0	9.0	11.0	11.5	4.5	9.3	10.3	10.0	13.3
23	14.5	14.8	13.5	15.0	15.0	13.3	17.0	16.8	16.5	15.8
24	17.5	23.8	6.5	4.5	5.5	4.0	18.5	20.0	10.0	4.5
25	15.0	19.0	16.0	15.5	16.0	17.5	13.5	14.8	15.5	15.5

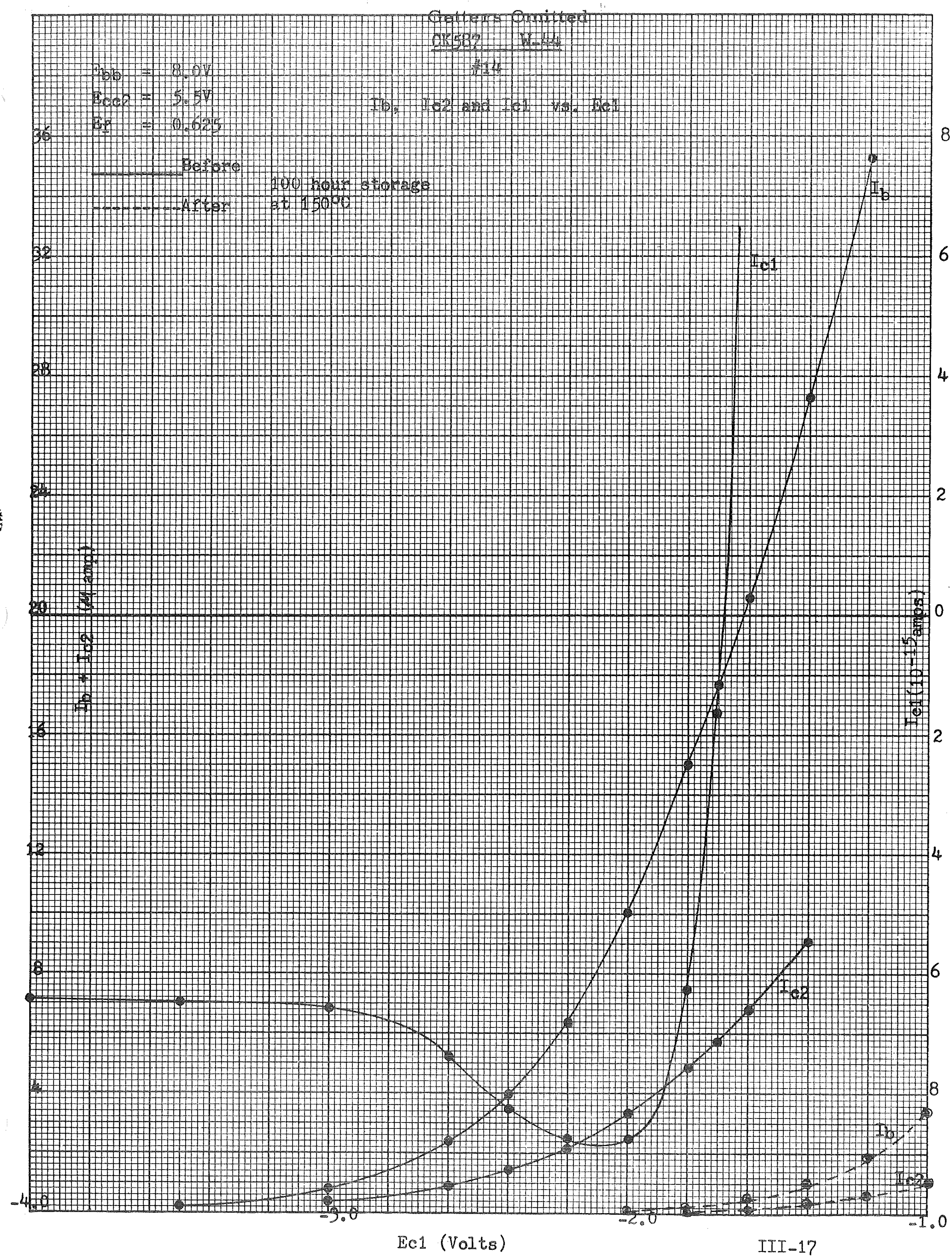
REGULAR CK5886

ELECTRICAL CYCLING (FILAMENT TURNED OFF AND ON)

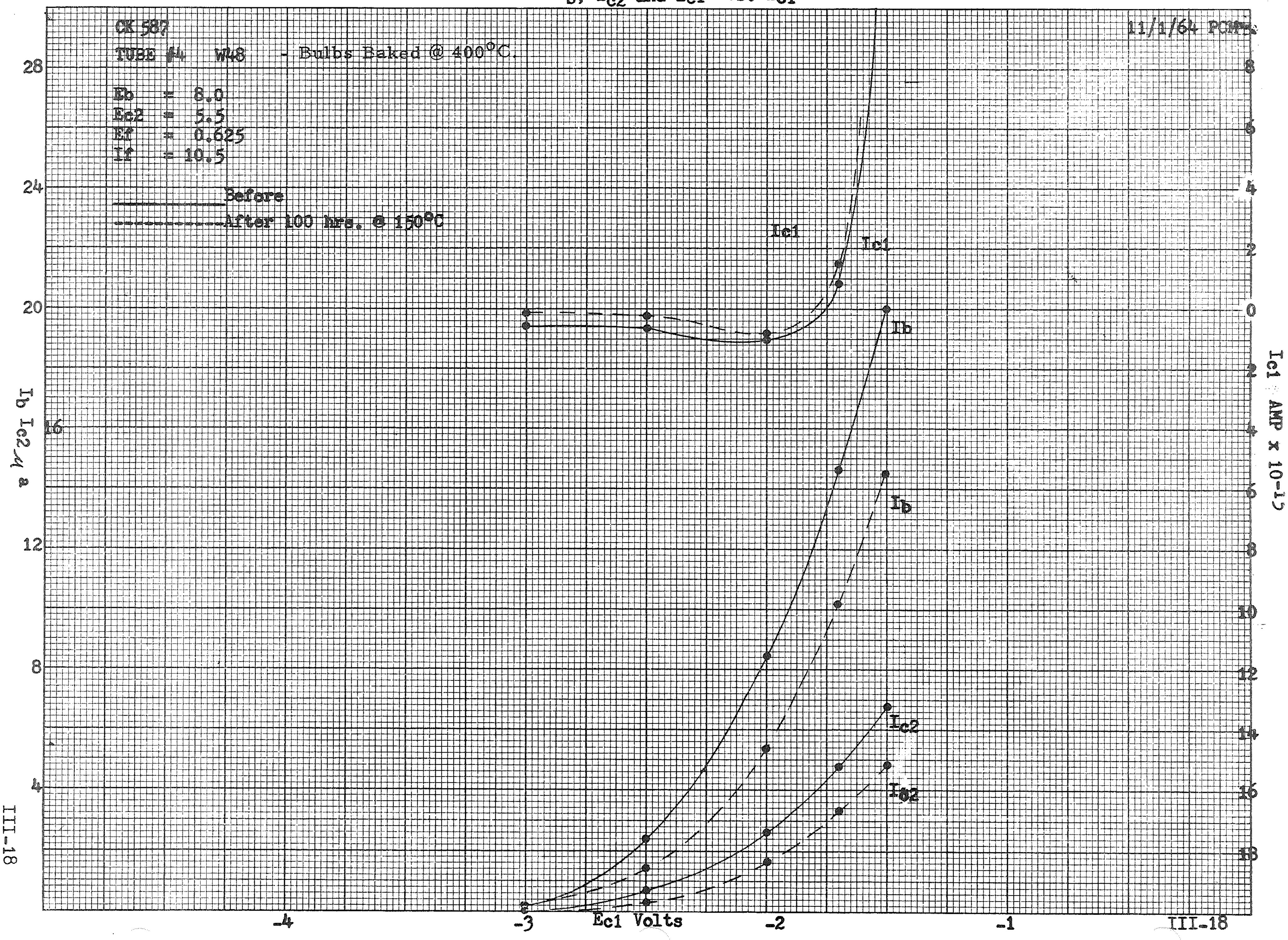
Tube No.	Direct Meter Readings/Cycle									
1	15.3	15.3	15.5	16.0	16.0	16.0	16.2	16.5	16.8	16.5
2	14.5	13.8	13.5	15.5	15.5	13.0	14.0	14.5	14.0	15.0
3	13.0	13.3	14.0	15.0	14.8	14.0	15.3	14.0	15.0	14.0
4	15.5	14.8	14.5	15.0	14.0	14.5	14.8	15.0	12.8	14.0
5	15.0	15.0	14.0	14.3	14.8	13.8	15.5	15.8	15.5	15.0
6	13.8	14.0	13.0	13.8	14.5	13.8	14.0	14.0	13.8	13.0
7	14.8	14.0	14.5	15.0	14.8	14.8	15.0	15.0	15.0	14.3
8	14.3	13.8	14.3	14.5	15.0	15.0	14.5	15.0	15.3	15.3
9	14.0	13.8	14.8	14.8	15.0	13.8	13.8	14.0	13.0	13.0
10	14.0	14.0	13.8	13.5	14.5	12.8	13.5	13.0	11.0	14.0
11	13.0	13.3	12.8	12.5	14.0	13.5	13.0	13.0	13.0	13.0
12	14.0	13.5	13.8	13.5	12.5	12.8	13.5	13.5	13.8	15.0
13	15.0	13.0	13.3	13.5	16.0	14.0	11.3	15.8	13.5	14.0
14	15.0	14.5	15.0	15.5	15.5	14.5	14.5	15.5	15.0	16.3
15	14.8	14.5	14.5	14.0	14.0	14.0	14.0	13.7	13.7	13.5
16	14.0	14.0	13.5	12.8	13.0	13.0	12.5	12.8	12.0	12.3
17	12.8	11.8	11.5	11.5	12.0	11.5	12.0	11.0	10.0	11.5
18	14.5	15.0	15.5	16.3	16.0	17.5	17.8	16.0	15.8	15.5
19	14.8	13.8	14.0	13.3	13.0	12.5	12.5	12.8	14.0	13.0
20	14.0	14.3	13.0	13.0	13.0	13.0	13.0	13.0	12.5	13.0
21	13.5	14.8	15.0	14.3	15.5	15.0	15.0	14.8	17.0	16.5
22	14.3	13.8	13.0	14.3	14.7	14.5	14.8	14.5	14.3	14.0
23	13.5	14.8	14.3	13.0	12.5	12.5	13.0	12.0	13.0	14.0
24	16.0	17.0	14.8	16.8	16.8	17.6	17.0	17.0	17.0	16.0
25	14.5	15.0	12.8	15.0	15.0	14.5	11.8	15.8	14.3	14.0



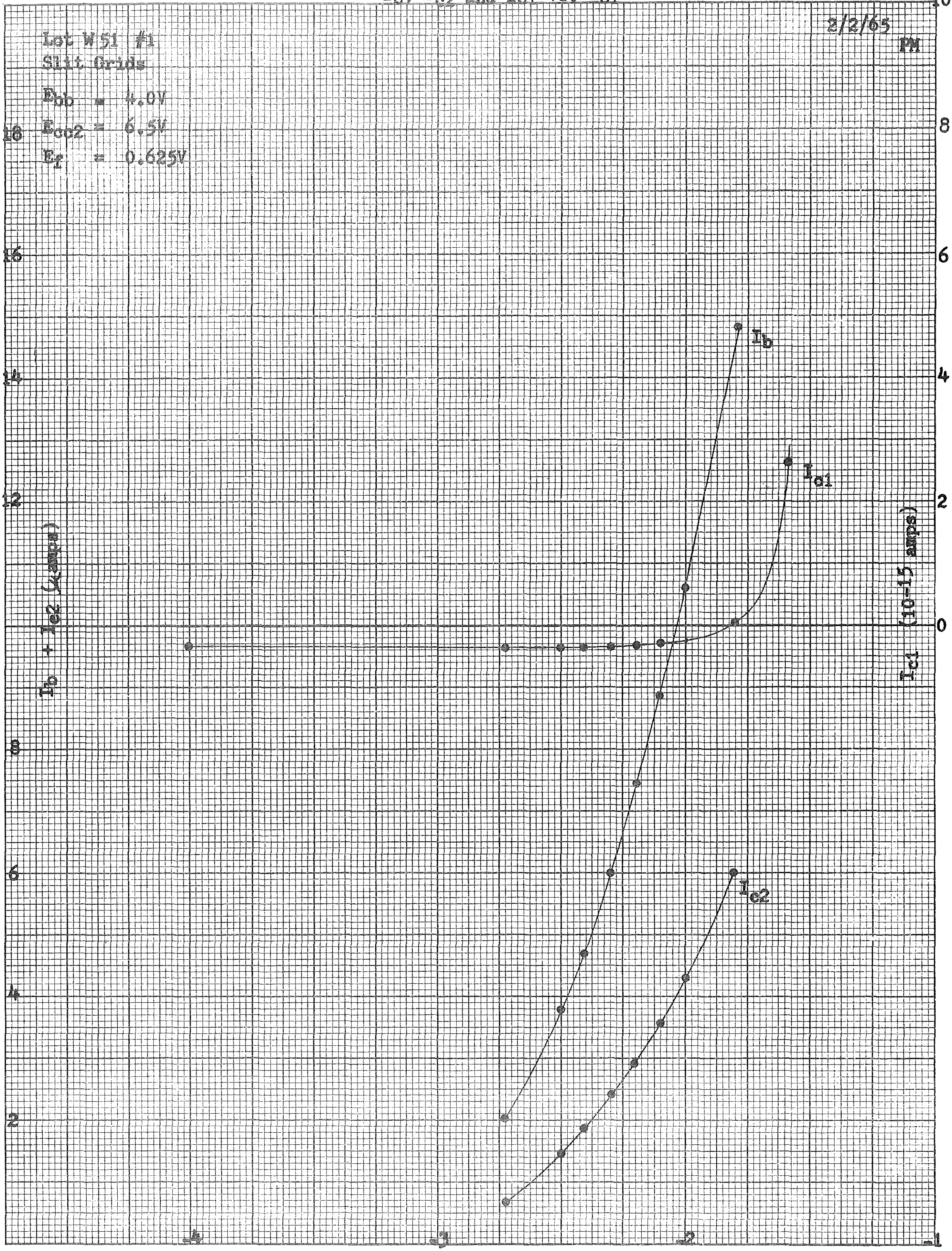
Aged Without "Hot Shot"
CK 587 LOT W 43
#18
Ib, Ic2, & Ic1 vs. Ec1
Ebb = 8.0 V
Ec2 = 5.5 V
Ef = 0.625V
Before 100 hr. Storage
After @ 150°C
Ic1
Ib
Ic2
Ib & Ic2 (μ amps)
Ic1 (10-15 amps)
Ec1 (Volts)
-3.0
-2.0
-1.0
36
32
28
24
20
16
12
8
4
8
6
4
2
0
2
4
6
8


Getters Omitted
OK587 W-44
#14
Ebb = 8.0V
Ecc2 = 5.5V
Ef = 0.625
Ib, Ic2 and Ic1 vs. Ec1
Before
After
100 hour storage
at 150°C
Ib + Ic2 (μ amp)
Ic1 (10-15 amps)
Ic1
Ib
Ic2
Ec1 (Volts)
-4.0
-3.0
-2.0
-1.0
36
32
28
24
20
16
12
8
4
8
6
4
2
0
2
4
6
8

I_b, I_{c2} and I_{c1} vs. E_{c1}



Ib, Ic2 and Ic1 vs. Ec1



Ec1 (Volts)

TEST W-63 - CK587 Samples Tested To The 8520 Specification

Test Conditions: E_f = 0.625V E_{cc2} = 5.5 Vd.c.
E_{bb} = 8.0 Vd.c. E_{c1} = -2.0 V Bias

Typical Distribution:

Tube #	I_b - μa	I_{c2} - μa	GM_1 - μmhos	I_{c1} x 10^{-15} amperes
1	4.5	1.9	12.3	-2.4
2	17.0	6.6	26.0	-3.4
3	3.8	1.3	10.3	-1.1
4	3.2	1.15	10.2	-0.5
5	6.8	2.4	15.1	-2.2
6	6.3	2.1	13.9	-1.4
7	15.0	5.3	17.1	-2.3
8	5.3	1.8	14.3	-2.7
9	8.0	2.5	17.8	-4.2
10	8.7	3.2	18.6	-1.6

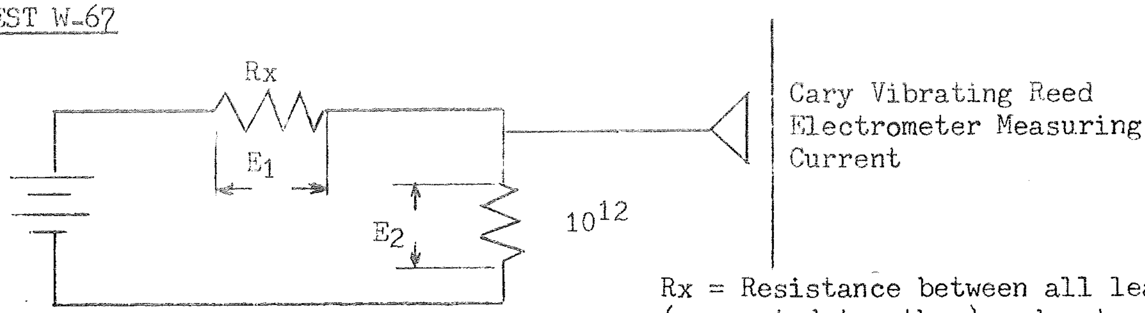
8520 Samples are those which pass the following limits:

I_b	5.0 - 20.0 μa
I_{c2}	1.0 - 5.0 μa
GM_1	10 - 25.0 μa
I_{c1}	$<$2.5 x 10^{-15} amperes

Characteristic values for 50 tube type CK587 samples follow:

Minimum	2.7	1.0	8.6	-0.5
Maximum	26.0	8.4	29.5	-4.2
Average	7.8	2.7	15.9	-1.8

TEST W-67



Rx = Resistance between all leads (connected together) and external envelope.

$$Rx = \frac{E_1 \times 10^{12}}{E_2}$$

After Heli-Arc Welding Only

Tube #	E_2 (MV)	Rx (ohms)
3B	0.3	3×10^{16}
4B	2.2	4×10^{15}
7B	1.0	1×10^{16}

After 300°C For One Hour On Varian (Vacuum approx. 5.0×10^{-8} Torr)

Tube #	E_2 (MV)	Rx (ohms)
3B	0.1	1×10^{17}
4B	0.5	2×10^{16}
7B	1.5	6.7×10^{15}

After 400°C For One Hour On Varian (Vacuum approx. 4.0×10^{-8} Torr)

Tube #	E_2 (MV)	Rx (ohms)
3B	0.7	1.4×10^{16}
4B	1.4	7.1×10^{15}
7B	1.4	7.1×10^{15}

After 500°C For One Hour On Varian (Vacuum approx. 4.2×10^{-8} Torr)

Tube #	E_2 (MV)	Rx (ohms)
3B	0.1	1.0×10^{17}
4B	1.8	5.5×10^{15}
7B	2.3	4.2×10^{15}

Two samples were completed which had readable emission after aging and burning. Mechanically these samples are good; electrically there is still work to be done.

Test Conditions: $E_f = 1.2V$; $E_b = E_{c2} = 15.0$ Vd.c.; $E_{c1} = 1.5$ V Bias.

Tube #	I_b - μa	I_{c2} - μa
3	12.5	25.0
4	3.2	9.8

TEST W-75

Preliminary samples of space charge grid pentode with plate halves rotated 180°.

Test Conditions: $E_f = 0.625V$
$E_{bb} = E_{cc3} = 6.0V$ D.C.
$E_{c2} = -2.5V$ Bias

Tube #	GM-μmhos	Rp (Read Screen to Plate)	E_{c1} Volts	I_{c1} -μa	I_b -μA
1	20.6	78K	-2.5V	145	14.9
2	15.4	105K	↓	138	9.5
3	21.8	76K	↓	138	23.7
4	20.0	85K	↓	148	18.8
8	18.5	94K	↓	129	13.7
9	16.2	101K	↓	147	11.0

Vary E_{c1} to maintain I_{c1} = 250μa

Tube #	GM-μmhos	Rp (Read Screen to Plate)	E_{c1} Volts	I_{c1} -μa	I_b -μA
1	26.6	57K	+3.4 V	250μA	21.2
2	19.4	80K	+3.45V	↓	14.0
3	29.5	52K	+3.51	↓	37.9
4	26.2	62K	+3.37	↓	28.5
8	23.0	71K	+3.52	↓	19.7
9	19.6	78K	+3.4	↓	14.8

TEST W-76

Test Conditions: E_f = 1.1V Vary E_{bb} to draw 150 μA I_b

E_{c1} = -6.0 Volts Bias

Tube #	Ebb-Volts D.C.	$I_{c1} \times 10^{-15}$ Amperes	E_{c1} Volts Bias	I_f-ma	Tubes Shipped To GSFC
1	6.1	-5.8	-6.0	13.0	X
2	6.2	-7.2	-6.0	12.6	X
3	6.7	-4.9	-6.0	12.9	X
4	5.5	-4.6	-6.0	13.7	X
5	6.3	-7.2	-6.0	13.0	X
6	7.0	-5.5	-6.0	12.6	X
7	6.8	-9.5	-6.0	12.7	
8	6.3	-6.3	-6.0	13.0	X
9	6.4	-5.0	-6.0	12.8	X
10	6.8	-5.5	-6.0	12.8	X
11	8.6 (climbs)	-	-6.0	13.6	
12	6.4	-8.0	-6.0	12.7	
13	7.7	-5.2	-6.0		
14	7.6	-10.0	-6.0	13.3	
15	6.8	-4.7	-6.0	12.5	X
16	6.2	-4.9	-6.0	12.7	X
17	6.7	-13.0	-6.0	12.9	
18	6.3	-6.2	-6.0	12.8	X
19	5.8	-6.5	-6.0	12.8	X
20	7.2	-5.8	-6.0	12.5	X
21	6.3	-7.8	-6.0	12.7	X
22	5.6	-6.0	-6.0	13.1	X
23	9.3	-	-6.0	14.1	
24	Over 15	-	-6.0	14.5	
25	5.6	-5.6	-6.0	12.6	X
26	6.2	-5.2	-6.0	12.4	X
27	5.2	-5.2	-6.0	12.9	X
28	5.7	-4.1	-6.0	13.1	X
29	Start 8.0 End 7.3	-12.5	-6.0	13.0	

TEST W-77

Preliminary Samples Of QV309 (German DC762 Inverted Triode)

Test Conditions: E_f = 1.1 Volts Vary E_{bb} to draw 400 μA I_b
E_{c1} = 2.5 Volts, I_b - 12-13 ma

Tube #	E_{bb} - Volts D.C.	$I_{c1} \times 10^{-15}$ Amperes	Tubes Shipped To GSFC
1	8.1	- 65.0	X
2	8.9	- 80.0	X
3	8.2	-100.0	X
4	8.4	- 74.0	X
5	8.85	-150.0	
6	8.6	-120.0	X
7	7.55	- 39.0	X
8	8.2	- 74.0	X
9	8.5	- 92.0	X
10	8.15	- 85.0	X
11	8.45	- 88.0	X
12	9.35	-210.0	
13	8.6	-150.0	X
14	9.2	-119.0	
15	9.15	-150.0	
16	Control Element to Anode Short	--	
17	9.0	-200.0	
18	7.95	- 63.0	X
19	7.95	- 58.0	X
20	9.05	-140.0	
21	8.3	-105.0	X
22	8.6	-120.0	X
23	8.85	-167.0	
24	8.0	- 76.0	X
25	8.35	-108.0	X
26	8.9	-125.0	
27	8.8	-130.0	X
28	8.6	-133.0	X
29	8.55	-117.0	X

TEST W-80 - Regular CK587 Except Open Frame #1 Grid (.035" Slit)

The following data taken under several test conditions is presented:

Test Conditions: E_f = 0.625V, E_{bb} = 4.0V D.C., E_{cc2} = 6.0V c.c, E_{c1} = -2.5V Bias

Tube # →	1	2	3	4	5	6	7	8	9	10
I_b - μA	72.0	78.0	40.0	25.0	42.0	50.0	70.0	73.0	71.0	25.0
I_{c2}- μA	24.5	32.0	15.5	8.4	13.5	18.0	25.5	35.5	27.5	8.6
GM_1- umhos	32.8	26.0	9.8	9.8	18.2	22.8	32.4	8.9	31.6	10.6
Rp-megohms	1.80	-	0.686	-	-	-	-	-	-	-
I_f - ma	10.5	10.5	10.3	10.6	10.3	10.4	10.2	10.7	10.5	10.2
I_{c1} x 10^{-15} amps	38.0	-1.1	-0.5	-1.5	-1.5	-1.3	-1.8	-1.2	-0.8	-9.0

Triode Connected: E_{bb} = E_{cc2} = 6.0V

Tube #	1	2	3	4	5	6	7	8	9	10
Mu_t	0.812	0.816	0.872	0.876	0.907	0.882	0.858	0.799	0.836	0.930
GM_t-umhos	45.6	52.6	18.4	14.0	27.0	34.3	50.3	49.7	48.1	15.0

Test Conditions: E_{bb} = 6.0V; E_{cc2} = 6.0V; E_{c1} = -2.5V Bias; E_f = 0.625V

Tube #	1	2	3	4	5	6	7	8	9	10
I_b - μA	73.0	83.0	42.0	27.0	43.0	53.0	73.0	85.0	74.0	28.0
I_{c2}- μA	24.0	27.0	14.0	8.0	13.0	17.0	24.0	28.0	25.0	9.0
GM_1-umhos	32.8	37.0	13.5	10.2	19.6	24.8	35.5	36.6	33.9	11.8
Rp-megohms	1.10	0.65	1.84	-	-	-	-	-	-	-

Test Conditions: E_{bb} = 5.0V D.C.; E_{cc2} = 6.0V D.C., E_{c1} = -2.5V Bias, E_f = 0.625V

Tube #	1	2	3	4	5	6	7	8	9	10
GM_1-umhos	-	35.4	13.0	-	-	-	-	33.0	33.5	-
Rp-megohms	-	0.41	1.16	-	-	-	-	0.34	0.77	-

TEST W-88 QV335 SAMPLES (CK5886 With Open Frame #1 Grid)

Test Conditions:

Pentode - $E_f = 1.25V$ $\quad E_{cc2} = 4.5V$ D.C.
$E_{bb} = 8.5V$ D.C. $\quad E_{c1} = -2.0V$ Bias

Triode - $E_f = 1.25V$ $\quad E_{c1} = -3.0V$ Bias
$E_{bb} = E_{cc2} = +10.5V$ D.C.

Typical Distribution

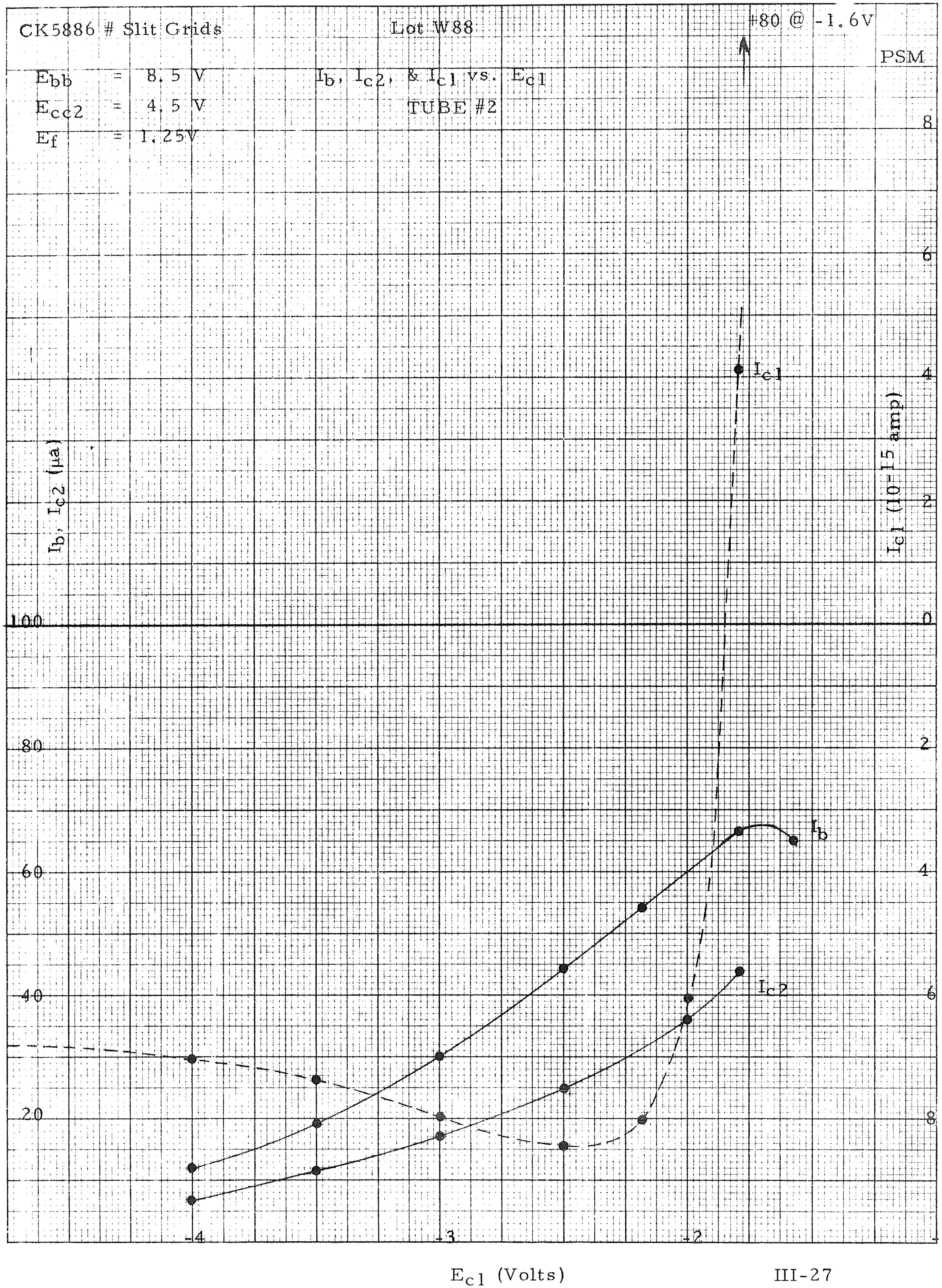
Tube #	I_b - μa	I_{c2}-μa	GM_1-μmhos	$I_{c1} x 10^{-15}$ Amps	I_f-ma	I_{bt}-μa	Mu_t	GM_t-μmhos
1	28	19	17.2	-4.0	9.9	485	1.04	140
2	46	29	27.5	-3.4	9.9	640	0.94	160
3	25	15	22.7	+0.1	9.6	555	0.84	138
4	44	25	31.0	-3.2	9.7	650	0.86	146
5	17	10	17.4	-1.6	9.8	550	0.82	144
6	35	22	23.7	-2.8	9.7	660	0.82	148
7	15	9	16.0	-1.5	9.7	510	0.84	135
8	50	29	32.5	-4.5	10.0	515	0.98	156
9	41	27	16.5	-15.0	9.9	585	0.96	151
10	67	38	38.1	-8.0	10.1	785	0.82	158

The Minimum, Maximum, and Average Characteristic Values
For 50 Samples Of Tube Type QV335 Follow:

Minimum	7	3	7.4	0	9.3	250	0.62	106
Maximum	83	49	42.5	-15.0	10.4	840	1.20	179
Average	42	26	27.8	-3.4	9.6	607	0.89	145

Note: Typical Values For Regular CK5886 Are Shown Below:

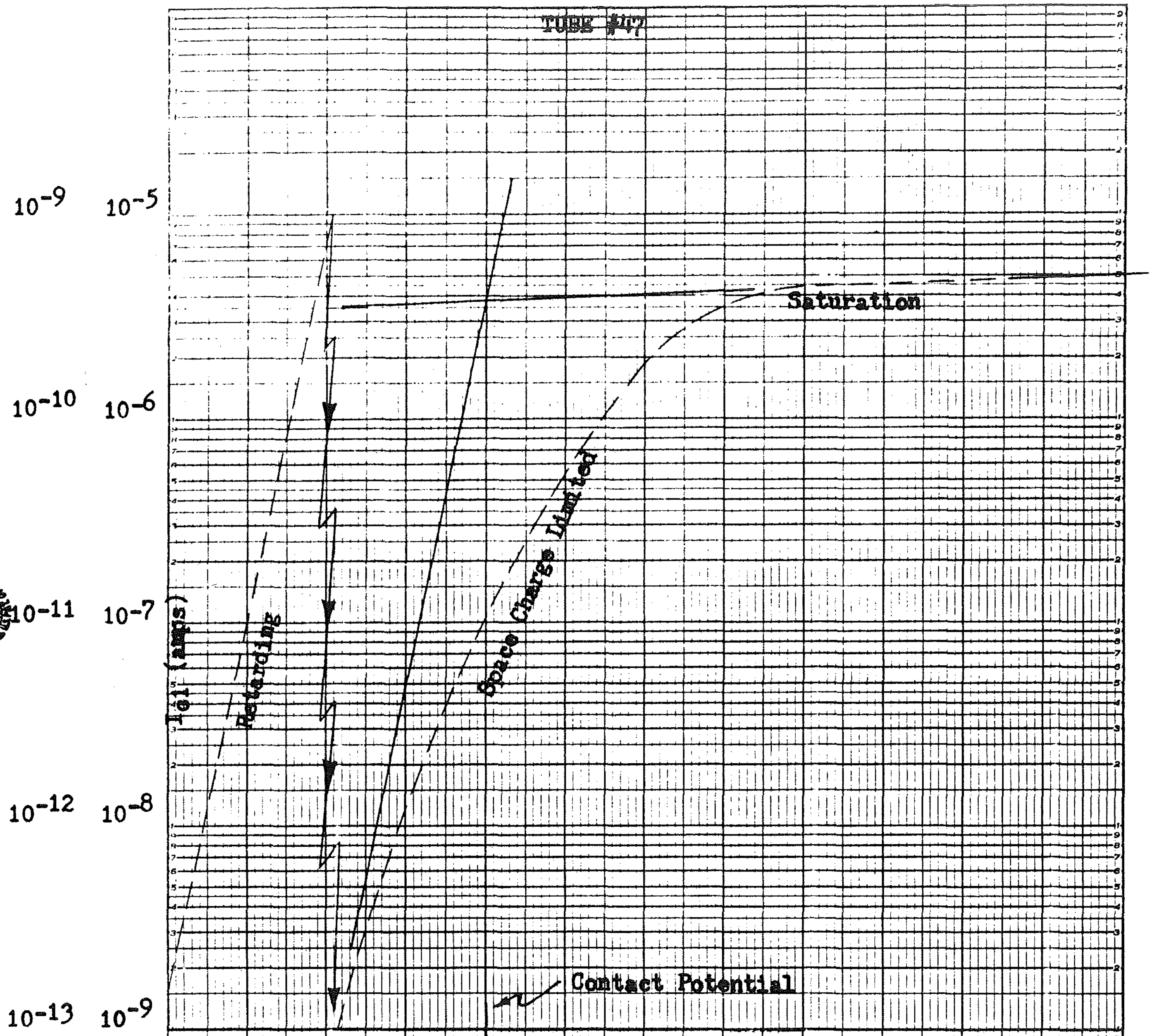
	6	3.6	14	-3.0	10.0	200	1.8	175


CK5886 # Slit Grids
Lot W88
#80 @ -1.6V
PSM
E_{bb} = 8.5 V
E_{cc2} = 4.5 V
E_f = 1.25V
I_b, I_{c2}, & I_{c1} vs. E_{c1}
TUBE #2
I_b, I_{c2} (μa)
I_{c1} (10-15 amp)
I_{c1}
I_b
I_{c2}
100
80
60
40
20
8
6
4
2
0
2
4
6
8
1
-4
-3
-2
E_{c1} (Volts)

LOT W 88

CK 5886 SPECIAL

TRUE CONTACT POTENTIAL BY INTERSECTION METHOD



TEST CONDITIONS:

E_f = 0.4V

E_{bb}-E_{cc2} = E_f minus

2-24-66

PSM

TEST 105

Five samples of the metal ceramic tube type QV291 were processed in T3 glass bulbs. These samples served a two fold purpose: they provided a chance to evaluate the use of ceramic spacers, which had been thinned down in the area against which the filament rests; and they provided finished samples for comparison with the metal ceramic QV291.

It is important to have good comparison standards for the metal ceramic QV291 as this product is somewhat of an unknown.

Test Conditions:

E_f = 0.625V

E_{bb} = 8.0V D.C.

E_{cc2} = 5.5V D.C.

E_{c1} = -2.0V Bias

Tube #	I_b - μa	I_{c2} - μa	R_p - megohms	GM_1 - μmhos
1	7.9	2.7	4.6	15.5
2	5.2	2.0	6.3	11.3
3	10.3	3.9	3.2	18.4
4	4.7	2.8	5.0	10.2
5	1.0	0.8	20.0	3.2

TEST W-106

Tube Type QV331 - A Cathode Electrometer Tube

Test Conditions:

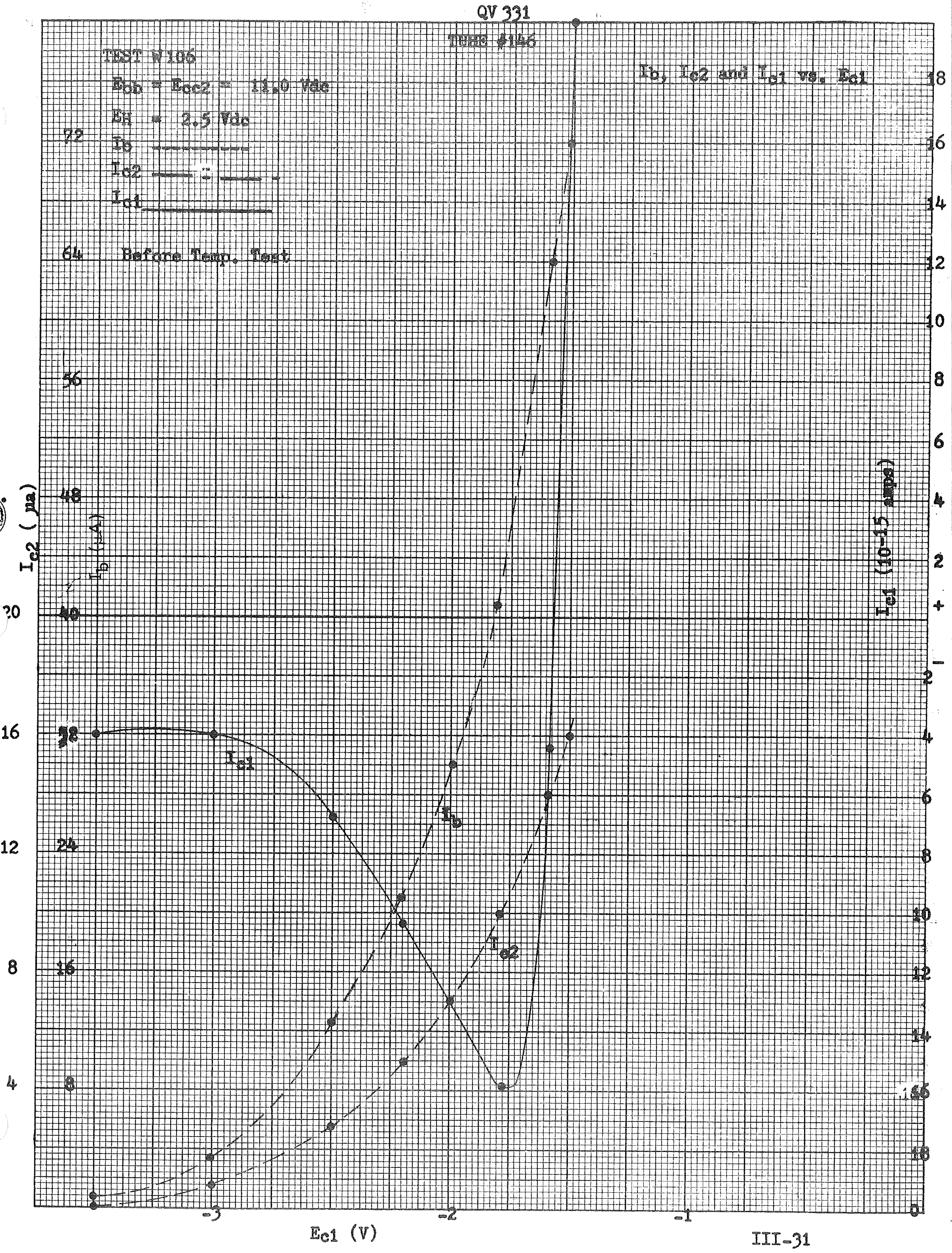
E_H = 2.5V
E_{bb} = E_{cc2} = 11.0V D.C.
E_{c1} = -2.2V Bias

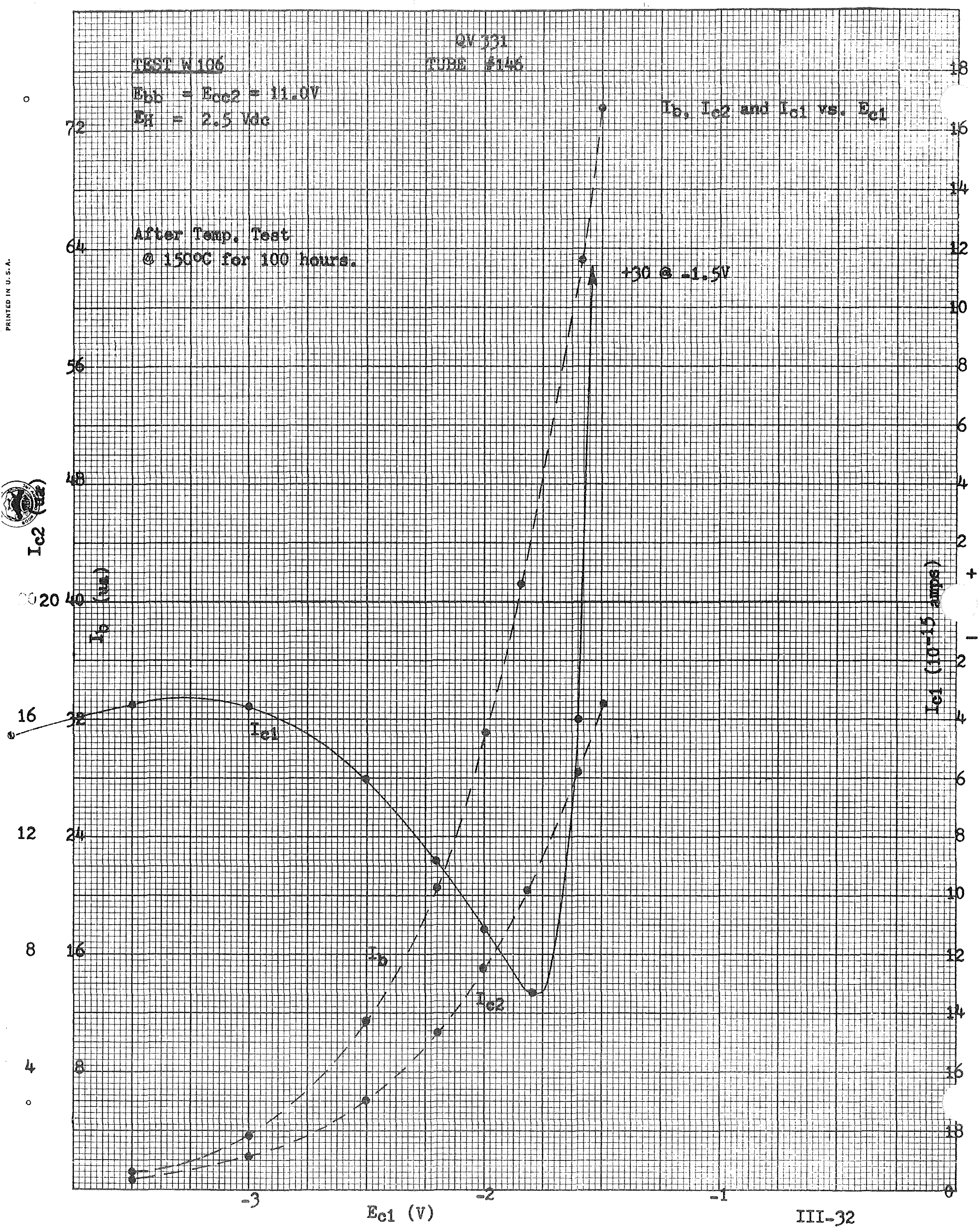
Typical Distribution

Tube #	I_b-μa	I_{c2}-μa	R_p-megohms	GM_1-umhos	Mu_t	$I_{c1} x10^{-15}$ Amps
1	13.9	2.25	1.20	36.7	4.21	-5.8
2	29.9	7.6	0.69	59.1	4.09	-16.7
3	26.7	5.25	0.75	58.0	4.23	- 9.0
4	8.15	1.7	1.70	25.8	3.95	- 8.4
5	13.0	2.85	1.20	38.2	4.40	- 8.9
6	22.6	5.4	0.93	51.0	4.33	-10.2
7	13.6	3.6	1.00	44.0	4.22	- 6.8
8	16.2	3.7	1.01	43.5	4.18	-53.0
9	11.5	1.8	1.38	32.2	4.02	- 0.6
10	15.0	3.75	1.10	39.8	4.21	- 8.0

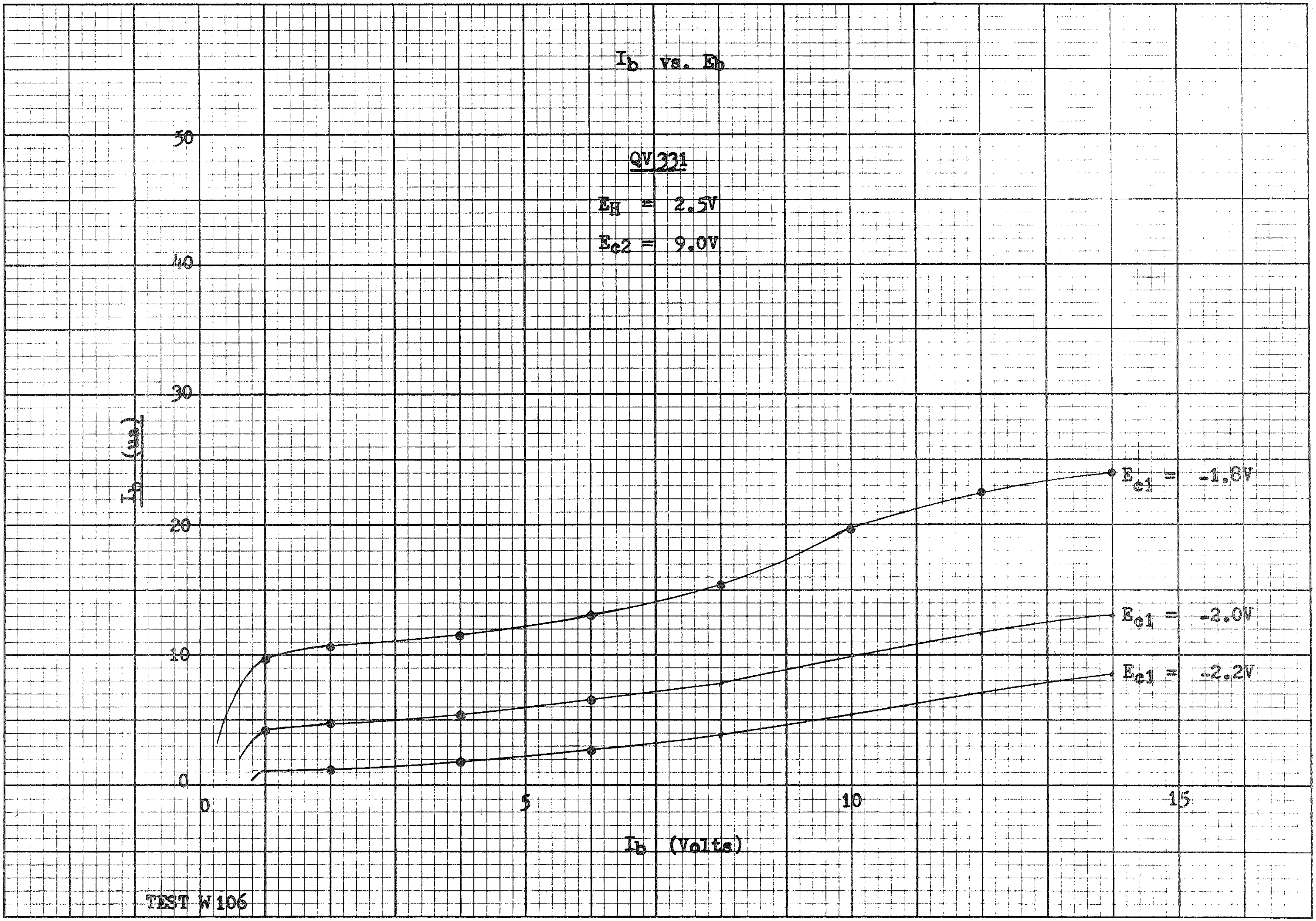
The Minimum, Maximum, & Average Characteristic Values For 50 Tube Type QV331 Samples Follow:

Minimum	7.4	1.7	0.64	22.4	3.51	- 0.6
Maximum	34.2	7.7	1.90	64.4	4.40	-53.0
Average	18.1	3.9	1.09	41.3	4.08	-11.3

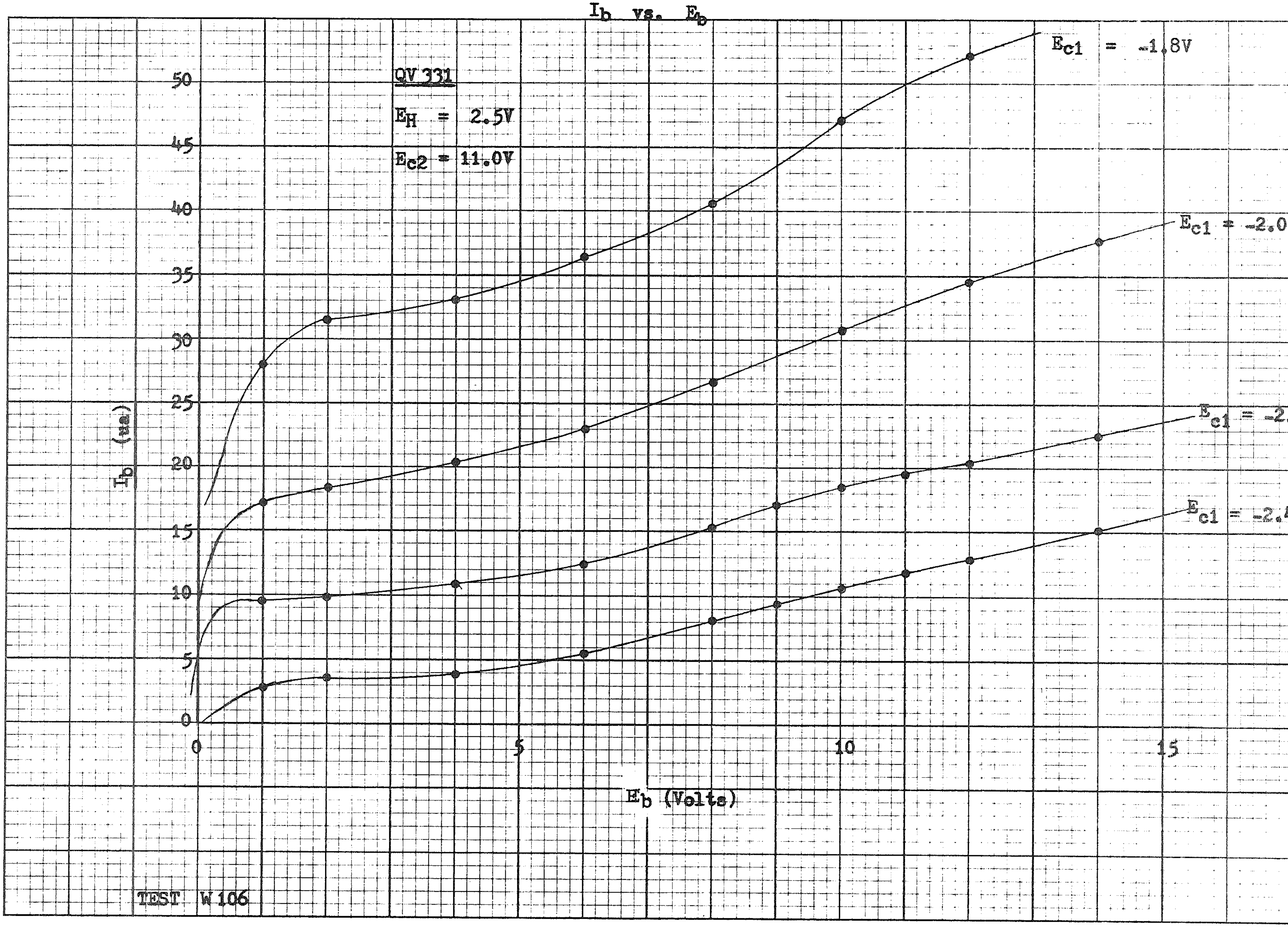

QV 331
TUBE #146
TEST W106
$E_{bb} = E_{cc2} =$ 11.0 Vdc
E_H = 2.5 Vdc
I_b
I_{c2}
I_{c1}
Before Temp. Test
I_b, I_{c2} and I_{c1} vs. E_{c1}
I_{c2} (μa)
I_b (μA)
I_{c1} (10-15 amps)
E_{c1} (V)
I_{c1}
I_b
I_{c2}



QV 331
TEST W 106
TUBE #146
Ebb = Ecc2 = 11.0V
EH = 2.5 Vdc
Ib, Ic2 and Ic1 vs. Ec1
After Temp. Test
@ 150°C for 100 hours.
+30 @ -1.5V
Ic1
Ib
Ic2
Ic2 (ua)
Ib (ua)
Ic1 (10^-15 amps)
Ec1 (V)


I_b vs. E_b
QV 331
E_H = 2.5V
E_{c2} = 9.0V
E_{c1} = -1.8V
E_{c1} = -2.0V
E_{c1} = -2.2V
I_b (ma)
I_b (Volts)
0
10
20
30
40
50
0
5
10
15
TEST W 106

III-33



I_b vs. E_b
QV 331
E_H = 2.5V
E_{c2} = 11.0V
E_{c1} = -1.8V
E_{c1} = -2.0V
E_{c1} = -2.2V
E_{c1} = -2.4V
I_b (ua)
E_b (Volts)
0
5
10
15
20
25
30
35
40
45
50
TEST W 106

III-34

RAYTHEON 561

LIFE TEST RECORD

File No. E-1

Acct. No.

Type QV331/7851 Test No. Submitted By Jack Williams Date 4-28-66

Special Features:- End Point

Room Temperature Es Is

Operate At:- Ef 2.5, Eb 11.0, Eg -2.2, Esg 11.0 Ehk Test At- Ef, Eb, Eg, Esg

#161

Date	Hrs.	I_f	10-15 AMPS I_{c_1}	I_B	I_{c_2}	(1) G_M	(2) G_M			+ HK	- HK
5-3-66	0	213	-13.2	12.2	3.38	30.8	21.7			0	0
5-9	144	215	-7.4	15.0	4.0	33.0	30.8			0	.016
5-20	336	217	-8.5	17.7	4.7	39.7	31.3			0	0
6-2	504	215	-8.5	19.0	5.1	39.0	32.0			0	0
6-13	768	210	-11.3	17.8	4.8	40.1	30.0			0	0

Hrs.Failure A

#162

Date	Hrs.	I_f	10-15 AMPS I_{c_1}	I_B	I_{c_2}	(1) G_M	(2) G_M			+ HK	- HK
5-3-66	0	213	-9.5	17.8	5.3	34.3	26.0			0	0
5-9	144	215	-8.8	19.0	6.0	33.0	24.0			0	.016
5-20	336	217	-10.3	21.7	6.1	39.3	30.0			0	0
6-2	504	215	-10.1	22.3	6.45	41.0	33.0			0	0
6-13	768	208	-10.8	21.5	6.10	39.2	30.5			0	0

Hrs.Failure B

#167

Date	Hrs.	I_f	10-15 AMPS I_{c_1}	I_B	I_{c_2}	(1) G_M	(2) G_M			+ HK	- HK
5-3-66	0	215	-9.5	12.8	2.2	28.0	20.0			0	0
5-9	144	215	-10.0	11.0	2.0	30.0	20.0			0	.016
5-20	336	217	-10.6	11.7	2.1	28.0	19.8			0	0
6-2	504	217	-10.0	11.7	2.2	28.8	23.0			0	0
6-13	768	212	-10.0	11.3	2.0	28.0	23.0			0	0

Hrs.Failure C

Tube No. #171

I_f	I_{c_1}	I_B	I_{c_2}	(1) G_M	(2) G_M			+ HK	- HK
215	-6.6	19.0	35.5	42.6	30.0			0	0
215	-7.5	20.0	4.0	45.8	35.3			0	.016
213	-6.4	21.0	3.8	45.0	33.0			0	0
215	-7.8	21.7	4.0	45.3	33.4			0	0
215	-6.4	20.0	3.65	43.0	32.2			0	0

Hrs.Failure D

Tube No. #172

I_f	I_{c_1}	I_B	I_{c_2}	(1) G_M	(2) G_M			+ HK	- HK
216	-8.3	21.8	4.0	43.4	33.2			0	0
215	-8.0	22.0	4.0	45.5	36.5			0	.016
217	-7.8	22.0	4.1	45.5	34.6			0	0
215	-9.4	20.8	4.0	43.0	34.3			0	0
212	-8.6	20.5	3.8	42.0	32.0			0	0

Hrs.Failure E

Hrs.Failure F

RAYTHEON Form 7561

LIFE TEST RECORD

File No. E-2 Acct. No.

Type QV331/7851 Test No. Submitted By Jack Williams Date

Special Features:- End Point

Room Temperature Es Is

Operate At:- Ef 2.5V, Eb 11.0, Eg -2.2, Esg 11.0 Ehk Test At:- Ef , Eb , Eg , Esg

Tube No. #173

Date	Hrs.	I_f	10-15 AMPS I_{c_1}	ua I_B	ua I_{c_2}	µ-mhos (1) GM	(2) GM	+ HK	- HK
5-3-66	0	215	-6.0	15.2	3.0	34.5	22.6	0	0
5-9	144	213	-7.3	17.0	3.5	37.8	25.4	0	.016
5-20	336	215	-5.6	14.7	3.8	36.7	23.2	0	0
6-2	504	213	-5.9	16.2	3.2	36.0	25.5	0	0
6-13	768	210	-5.8	14.5	2.8	33.7	24.0	0	0

Tube No. #174

Date	Hrs.	I_f	I_{c_1}	I_B	I_{c_2}	(1) GM	(2) GM	+ HK	- HK
5-3-66	0	213	-12.0	24.5	5.55	45.5	34.0	0	0
5-9	144	213	-9.3	24.8	5.62	46.4	37.2	0	.016
5-20	336	215	-8.7	22.5	5.1	43.7	34.5	0	0
6-2	504	215	-10.3	24.0	5.45	43.2	36.0	0	0
6-13	768	212	-9.1	23.1	5.2	43.0	33.5	0	0

Tube No. #175

Date	Hrs.	I_f	I_{c_1}	I_B	I_{c_2}	(1) GM	(2) GM	+ HK	- HK
5-3-66	0	214	-10.5	29.5	5.52	54.0	39.3	0	0
5-9	144	215	-10.0	32.0	5.8	56.1	40.8	0	.016
5-20	336	215	-9.5	29.5	5.35	53.3	41.0	0	0
6-2	504	215	-10.0	30.0	5.5	54.3	43.2	0	0
6-13	768	212	-10.0	30.0	5.6	55.0	42.0	0	0

Hrs.Failure A B C

Tube No. #176

I_f	I_{c_1}	I_B	I_{c_2}	(1) GM	(2) GM	+ HK	- HK
217	-8.2	16.0	3.45	34.2	23.8	0	0
217	-8.3	17.3	3.85	38.8	28.0	0	.016
218	-7.4	17.5	3.65	37.6	25.0	0	0
218	-7.6	17.0	3.6	36.6	27.0	0	0
217	-8.1	16.1	3.4	34.3	23.0	0	0

Tube No. #178

I_f	I_{c_1}	I_B	I_{c_2}	(1) GM	(2) GM	+ HK	- HK
215	-5.2	12.8	2.5	31.3	19.5	0	0
215	-4.3	13.5	2.75	33.0	22.8	0	.016
217	-4.9	12.5	2.4	30.0	19.4	0	0
217	-4.4	13.2	2.6	31.0	21.3	0	0
212	-4.9	12.2	2.25	29.8	20.0	0	0

Hrs.Failure D E F

RAYTHEON 561

LIFE TEST RECORD

File No. E-1 Acct. No.

Type 8520 Test No. Submitted By L.Henry Date 11-2-64

Special Features:- End Point 100 Hrs. Icl 3.5 X 10 $^{-15}$, Gm 7 umhos Min.

10,000 Hrs. Info Es Is

Operate At:- Ef .625, Eb 8.0, Eg -2.0, Esg 5.5 Ehk Test At:- Ef, Eb, Eg, Esg

Tube No.		A				B				C			
Date	Hrs.	10-15 AMPS I_{c_1}	ua I_B	ua I_{c_2}	u-mhos G_m	10-15 AMPS I_{c_1}	ua I_B	ua I_{c_2}	u-mhos G_M	10-15 AMPS I_{c_1}	ua I_B	ua I_{c_2}	u-mhos GM
11-4-64	0	-2.2	6.8		15.1	-1.6	8.7		18.6	-2.4	6.3		15.9
11-9	121		8.0	2.0	15.0		8.2	2.7	17.6		7.8	2.2	16.8
11-17	312												
11-24	480		7.0	2.3	15.2		8.7	3.1	18.3		6.5	2.0	16.1
12-16	1008	-3.2	6.1	1.9	13.8	-1.7	5.4	1.8	13.1	-3.4	5.9	1.7	15.0
3-26-5	2016	-2.2	6.3	2.0	13.9	-2.3	5.9	2.0	13.9	-2.5	5.5	1.6	14.5
11-24	6000	-1.7	5.0	1.6	11.9	-4.5	5.0	1.8	12.6	-2.0	3.5	1.08	10.6
2-25-6	8000	-1.0	4.7	1.5	11.4	-1.3	5.0	1.8	12.4	-0.8	3.5	1.11	10.5
5-9	10,000	-1.4	5.1	1.7	11.8	-1.2	5.5	2.0	13.1	-1.1	4.1	11.2	11.3
Hrs.Failure		A #5				B #10				C #16			

Tube No.		D				E				F			
	0	-1.2	7.9	[illegible]	17.9	-2.3	9.4		19.0				
			6.0	1.3	18.5		8.0	2.2	15.0				
			7.5	2.3	17.1		9.4	2.3	18.7				
		-2.3	6.6	1.9	15.7	-2.8	7.1	1.6	15.4				
		-1.8	7.1	2.1	16.5	-2.2	8.4	1.9	17.1				
		-4.0	5.2	1.50	13.4	-2.4	6.1	1.35	13.6				
		-1.0	5.1	1.5	13.2	-1.3	6.1	11.4	13.6				
		-1.2	5.5	1.6	13.5	-1.4	6.3	1.4	13.6				
Hrs.Failure		D #20				E #28				F			

APPENDIX IV

Processing Schedules

EES - Electrometer Exhaust Schedule

EES-1 (Trolley)

Step		Time
1	Bake-Out (Oven Temp 650^{o}F.)	20 Min.
2	Heat Deflectors Dull Red (R.F. Induction Heating)	15 Sec.
3	Flash Getter	
4	Breakdown Filament (17.0 ma)	15 Sec.
5	Flash Getter	
6	Tip-Off Tube	

EES-2 (Trolley)

1	Bake-Out (650^{o}F.)	20 Min.
2	Heat Deflectors Dull Red	15 Sec.
3	Flash Getter	
4	Breakdown Filament (95.0 ma)	15 Sec.
5	Flash Getter	
6	Tip-Off Tube	

EES-3 (Modified Hoffman Rotary)

Track Lighting Position	1	2	3	4	5	6	7	8	9	10
Plug Position						3-11-11	3-11-9		3-11-1	
Track Current (ma)						17.5	17.0		17.0	
R.F. Heating	*B_1	*B_2	*B_2		Flash					Flash
Resistance Loads (ohms)						2KΩ	2KΩ		2KΩ	
R-F Output (Amperes)	.4	1.45	1.45							

* = -- 4 Turn Double Wound Round Coils
Oven Temperature: 400^{o} C.

EES-4 (Trolley)

Step		Time
1	Bake-Out (650°F.)	20 Min.
2	Heat Shield Dull Red	15 Sec.
3	Flash Getter	
4	Breakdown Filament (17.0 ma)	15 Sec.
5	Flash Getter	
6	Tip-Off Tube	

EES-5 (Trolley)

1	Bake-Out (Oven Temp. 650°F.)	20 Min.
2	Heat Deflectors Dull Red	15 Sec.
3	Flash Getter	
4	Breakdown Filament (65.0 ma)	15 Sec.
5	Flash Getter	
6	Tip-Off Tube	

EES-6 (Trolley)

1	Bake-Out (650°F.)	20 Min.
2	Heat Plates Dull Red	15 Sec.
3	Flash Getter	
4	Light Heater Until Complete Gas Clean-up (Ion Gauge)	
5	Flash Getter	

EES-7 (Modified Hoffman Rotary)

Speed: 700/hour

Track Lighting Position	1	2	3	4	5	6	7	8	9	10
Plug Position						5-6-1	5-1-1	5-1-1		
Track Current (ma)						15.5	15.0	15.0		
R.F. Heating	$*B_1$	$*B_1$	$*B_2$	$*B_2$	Flash					Flash
Resistance Loads (ohmns)						3K	3K	3K		
R-F Output (Amperes)	3.9	3.9	6.0	6.0						

$*$ = 4 Turn Single Wound Round

Oven Temperature - 400° C.

EES-8 (SEALEX) SPEED: 600/hour

Track Lighting Position	1	2	3	4	5	6	7	8	9	10
Plug Position	Off	Off	4-7	4-6	4-6	4-6	4-6	4-6	4-6	4-6
Track Voltage	-	-	4.8	5.4	5.6	5.6	5.6	5.6	5.5	5.0
R.F. Heating		B1	B1	B2	B2	B3	B3			
R. F. Output (milliamperes)		75	75	50	50	85	85			
Coil Type		------8 Turn Double Wound------								

Oven Temperature: 400°C.

EES-9 (VARIAN VAC ION SYSTEM)

Step		Time
1	Bake-Out 425°C	1 Hour
2	Breakdown Filament (17.0 ma)	15 Sec.
3	Pinch-Off Tube	

EES-10 (TROLLEY)

1	Bake-Out (Oven Temperature: 650°F.)	20 Min.
2	R.F. Bombard Metal Elements Dull Red	15 Sec.
3	Flash Getter	
4	Draw 28.0 ma Filament Current Until Gas Clean-up Is Complete-Check With Ion Gauge	
5	Draw 24.0 ma Filament Current	12 Sec.
6	Reflash Getter	
7	Tip-Off Tube	

EES-11 (TROLLEY)

1	Bake-Out (650°F.)	20 Min.
2	Heat Deflectors White Hot	15 Sec.
3	Flash Getter	
4	Breakdown Filament (17.0 ma)	15 Sec.
5	Flash Getter	
6	Tip-Off Tube	

EES-12 (TROLLEY)

Step		Time
1	Bake-Out (650°F.)	20 Min.
2	Bomb Deflectors Cherry Red	15 Sec.
3	Flash Getter	
4	Breakdown Filament (10 ma)	15 Sec.
5	Flash Getter	
6	Tip-Off Tube	

EES-13 (TROLLEY)

1	Bake-Out (650°F.)	20 Min.
2	Bomb Deflectors Cherry Red	15 Sec.
3	Flash Getter	
4	Breakdown Filament (20 ma)	15 Sec.
5	Flash Getter	
6	Tip-Off Tube	

EAS - ELECTROMETER AGING SCHEDULE

EAS-1

Step	E_f-V	Ebb-V d.c.	E_{cc2}-V d.c.	E_{c1} - V Bias	I_b -µa	Time
1	0.7	Ground	Ground	Ground		Load
2	2.2	Ground	Ground	Ground		30 Sec.
3	0.7	20	20	Ground	(250-350)	10 Min.
4	2.2	Ground	Ground	Ground		30 Sec.
5	0.7	20	20	- 3	(160)	10 Min.
6	0.7	15	15	- 3	(120)	48 Hours

EAS-2

1	1.4	Ground	Ground	Ground		Load
2	3.0	Ground	Ground	Ground		45 Sec.
3	1.4	20	20	Ground		5 Min.
4	3.0	Ground	Ground	Ground		45 Sec.
5	1.4	10	10	Ground		15 Min.
6	1.4	15	15	Ground		48 Hours

EAS-3

1	0.7	Ground	Ground	Ground		Load
2	2.2	Ground	Ground	Ground		30 Sec
3	0.7	15	15	Ground	(200-300)	10 Min.
4	2.0	Ground	Ground	Ground		30 Sec.
5	0.7	13	13	- 3	(120)	10 Min.
6	.7	13	13	- 3	(120)	72 Hours

EAS-4

1	0.7	Ground	Ground	Ground		Load
2	2.2	Ground	Ground	Ground		30 Sec.
3	0.7	15	15	Ground	(200-300)	10 Min.
4	2.2	Ground	Ground	Ground		30 Sec.
5	0.7	15	15	- 3		10 Min.
6	0.7	12	12	- 3	(120)	48 Hours

EAS-5

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	Ec1 - V_{Bias}	I_b - a	Time
1	1.4	Ground	Ground	Ground		Load
2	1.9	Ground	Ground	Ground		45 Sec.
3	1.2	14	14	Ground	(600)	10 Min.
4	1.2	14	14	-3	(500)	72 Hours

EAS-6

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	Ec1 - V_{Bias}	I_b - a	Time
1	.7	Ground	Ground	Ground		Load
2	2.2	Ground	Ground	Ground		30 Sec.
3	0.7	15.0	15.0	Ground	(200-300)	10 Min.
4	0.7	13.0	13.0	- 3	(120)	10 Min.
5	0.7	13.0	13.0	- 3	(120)	72 Hours

EAS-7

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	Ec1 - V_{Bias}	I_b - a	Time
1	1.1	Ground	Ground	Ground		15 Hours
2	0.7	15.0	15.0	Ground		10 Min.
3	0.7	8.0	5.5	- 2.5	(8)	24 Hours

EAS-8

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	Ec1 - V_{Bias}	I_b - a	Time
1	0.7	Ground	Ground	Ground		Load
2	2.2	Ground	Ground	Ground		30 Sec.
3	0.7	13.0	13.0	- 3	(120)	48 Hours
4	0.7	8.0	5.5	-2.5	(8)	48 Hours

EAS-9

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	Ec1 - V_{Bias}	I_b - a	Time
1	0.6	Ground	Ground	Ground		Load
2	1.0	Ground	Ground	Ground		20 Sec.
3	0.5	10	10	Ground	(300)	10 Min.
4	0.5	10	10	-3	(100)	72 Hours

EAS-10

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	Ec1 - V_{Bias}	I_b - a	Time
1	1.5	5.0		No Conn.	(500-1000)	72 Hours

EAS-11

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	E_{c1}-V Bias	I_b-μa	Time
1	1.5	8.0		No Conn.	(350-700)	72 Hours

EAS-12

					E_{c3}		
1	0.7	Ground	Ground	Ground			Load
2	2.0	Ground	Ground	Ground			20 Sec.
3	0.7	10	10	Ground	10	(110)	72 Hours

EAS-13

Step	E_f-V	E_{bb}-V d.c.	E_{cc2}-V d.c.	E_{c1}-V Bias	I_b	I_{c2}	Time
1	4.0	Ground	Ground	Ground			Load
2	6.5	Ground	Ground	Ground			1 Min.
3	4.0	--------Cycle 30 Seconds On/Off--------					30 Min.
4	3.5	150.0	100.0	Ground	11.0 ma	2.0 ma	15 Min.
5	3.5	100.0	100.0	Ground	9.5 ma	4.0 ma	20 Hours
6	3.5	50.0	50.0	Ground	4.0 ma	1.0 ma	72 Hours
7	2.5	11.0	11.0	-2.2	20.0 a	4.5 a	24 Hours

EAS-14

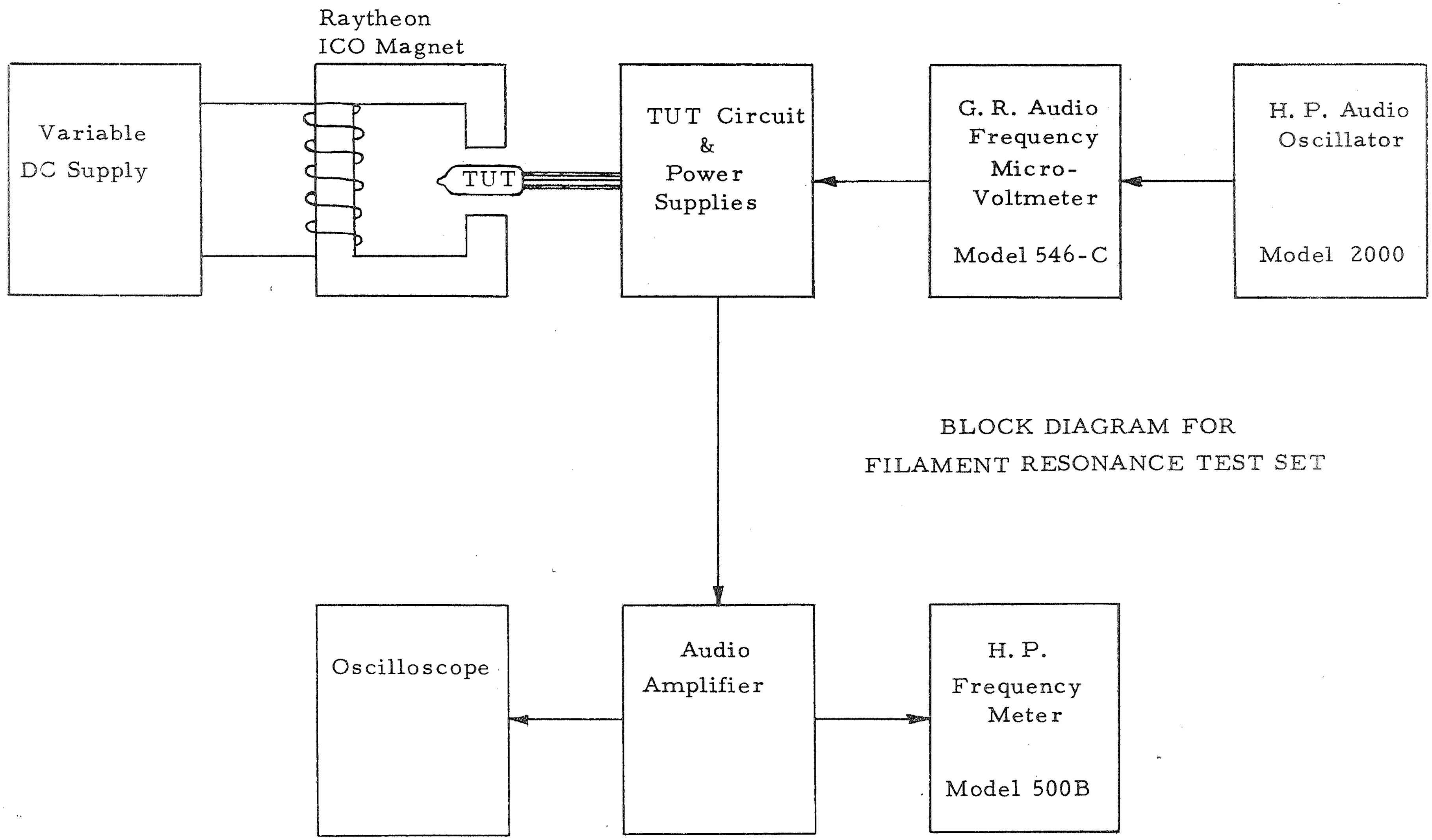
1	0.7	Ground	Ground	Ground			Load
2	2.2	Ground	Ground	Ground			20 Sec.
3	1.2	15	15	Ground	10 a		72 Hours

EAS-15

1	0.7	Ground	Ground	Ground			Load
2	2.2	Ground	Ground	Ground			30 Sec.
3	0.7	10 V d.c.	10 V d.c.	Ground	90 μa	60 μa	10 Min.
4	2.2	Ground	Ground	Ground			30 Sec.
5	0.7	10 V d.c.	10 V d.c.	-3 V_{Bias}	50 μa	25 μa	72 Hours

APPENDIX V

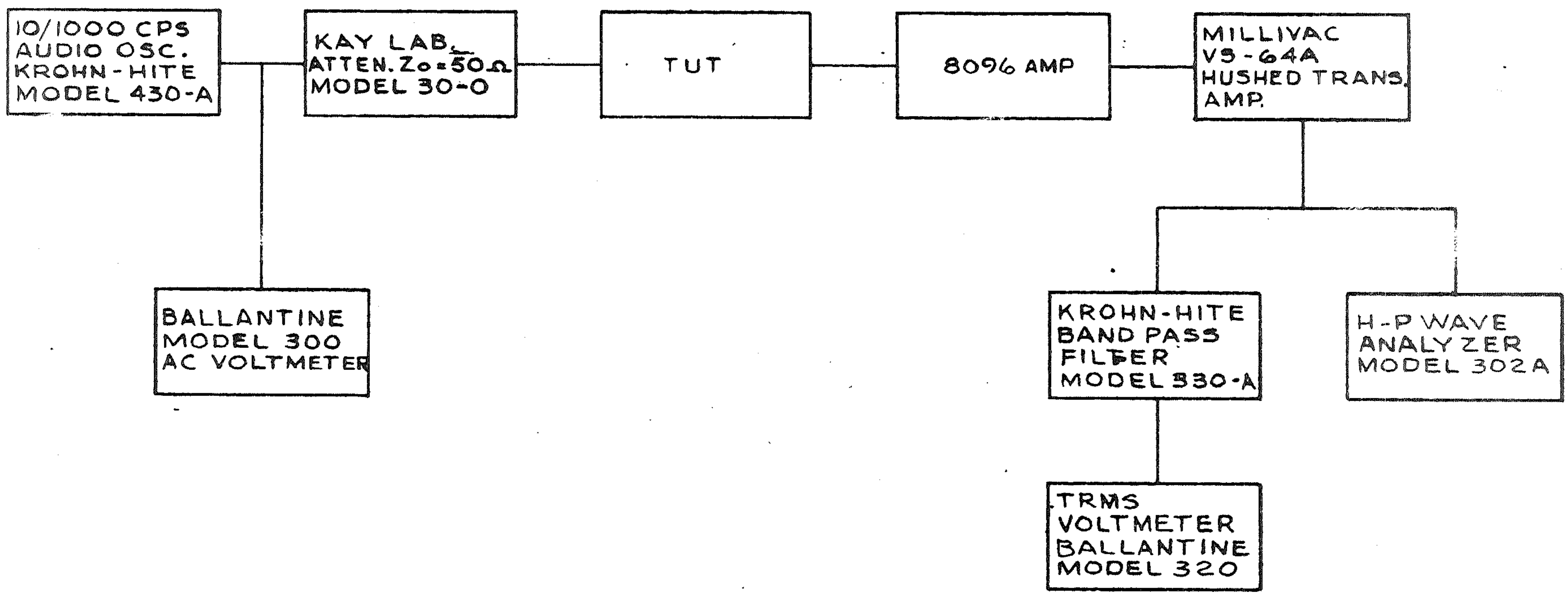
SCHEMATICS - SPECIALIZED TEST EQUIPMENT



BLOCK DIAGRAM FOR
FILAMENT RESONANCE TEST SET

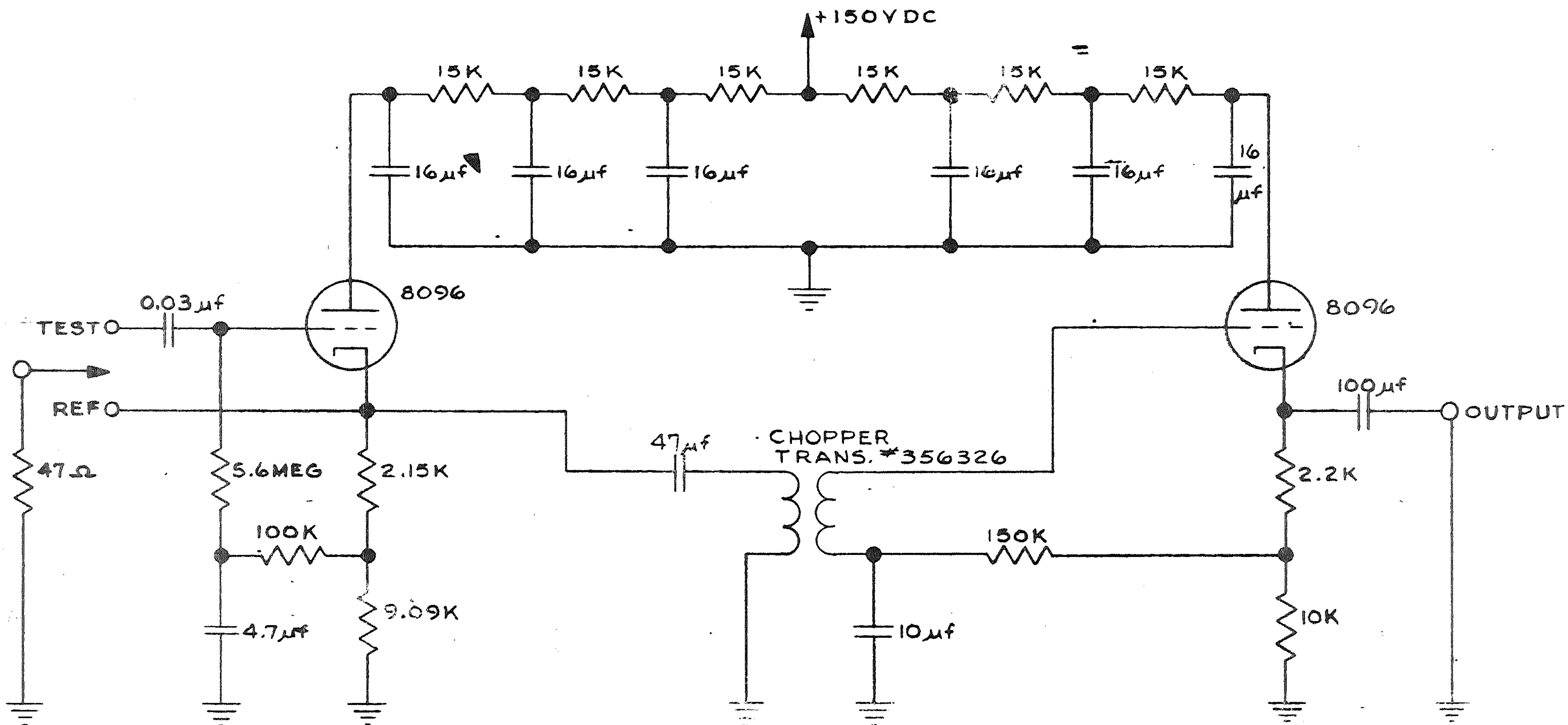
TUT = Tube Under Test
H. P. = Hewlett Packard
G. R. = General Radio

QUIESCENT SPOT NOISE BLOCK DIAGRAM

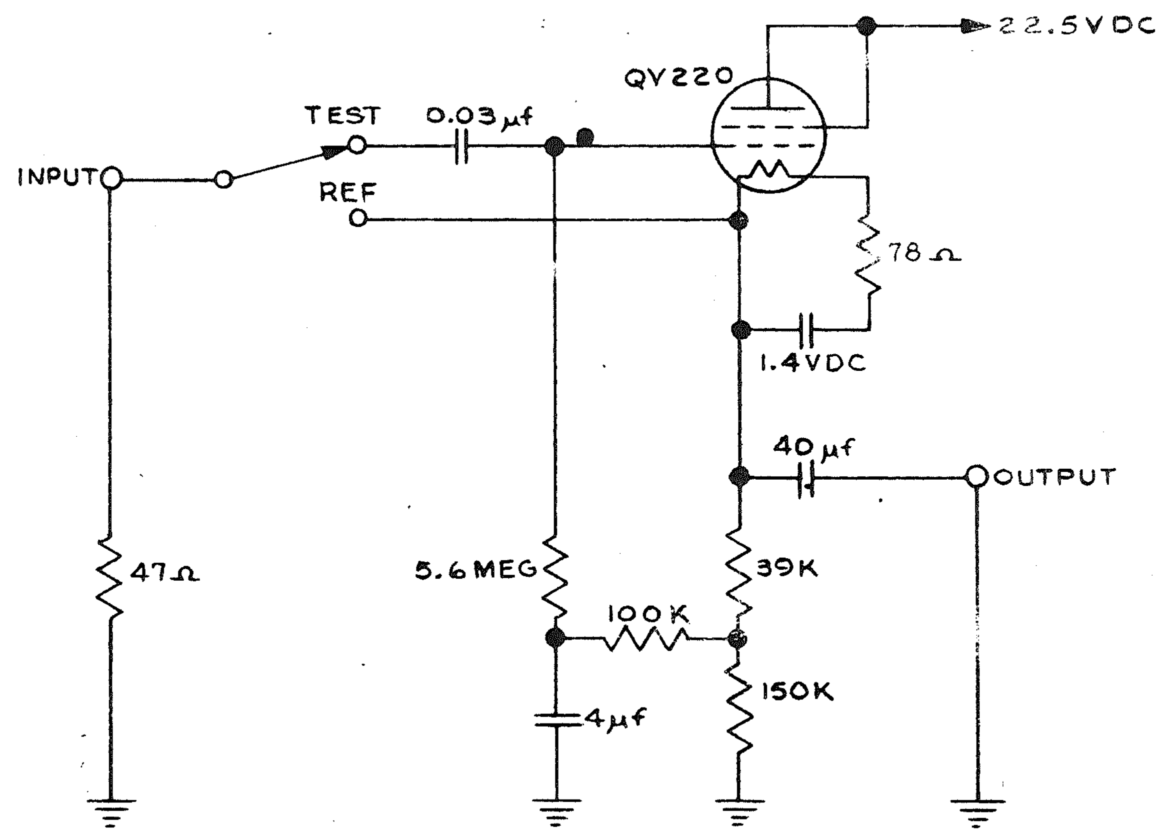


V-3

QUIESCENT SPOT NOISE 8096 AMPLIFIER



QUIESCENT SPOT NOISE TUT CIRCUIT



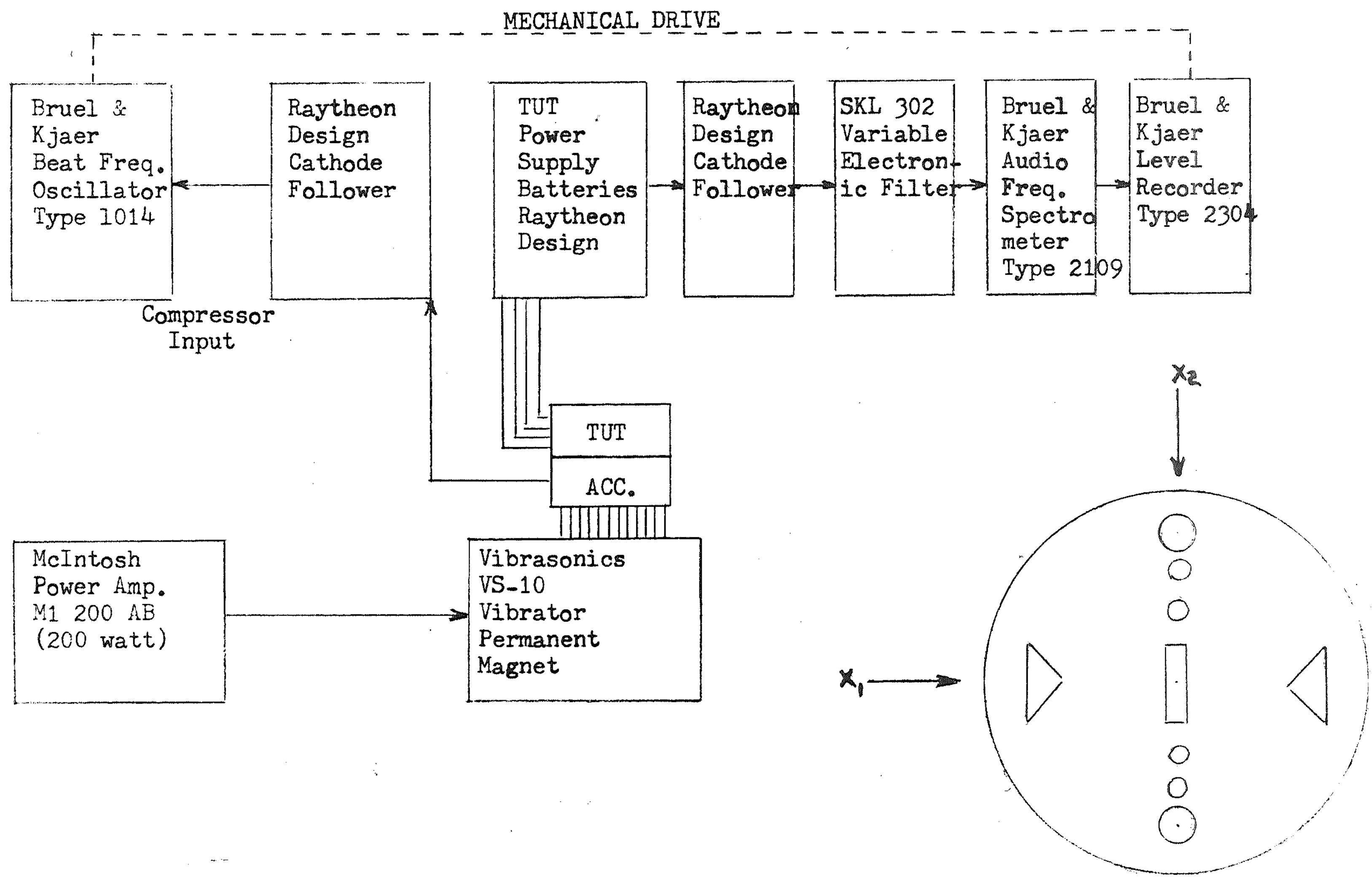
NO.	DATE	B	REVISION	DWN.			SCALE	
				CHK.			MAT'L.	
				APPD			Q'TY.	

VIBRATION TEST BLOCK DIAGRAM

(SWEEP FREQUENCY)

PLANT ENGINEERING DEPT.
RAYTHEON COMPANY, NEWTON, MASS.

ALL DIMENSIONS UNLESS OTHERWISE SPECIFIED MUST BE HELD TO A TOLERANCE, FRACTIONAL DIM. DEC. DIM.



FORM 5402 B. L. M. INC. 72166

Sweep Frequency Vibration Test Notes

The tubes shall be fastened rigidly to the vibration platform and vibrated with simple harmonic motion over a frequency of 200 to 3000 Hz at a peak acceleration value of 5G. In any single complete excursion, the acceleration over the frequency range shall be within $\pm$ 10 percent of the reference acceleration at 200 Hz. At all frequencies from 200 to 3000 Hz, the total harmonic distortion of the acceleration waveform shall be less than 5%.

The frequency shall increase from 200 to 3000 Hz with approximately logarithmic progression versus time and shall require one (1) minute minimum, three (3) minutes maximum, to traverse the range. Each tube shall be vibrated in position X1 and X2, except that if the cumulative result of tests on 50 or more tubes of a given construction shows that more than 75 percent of the tubes have higher output voltage on one position, subsequent measurements need only be taken in the position giving the higher readings.

The specified voltages shall be applied to the tube during vibration. The value of Eb under test conditions shall be regarded as Ebb, and shall be applied to the tube through the specified resistor, (Rp). The voltage (ep) produced across the resistor, (Rp), as a result of vibration, shall be measured with a suitable recording device. This device shall have an appropriate voltage range and shall have the ability to indicate with an error of less than 10 percent, the peak to peak value of a sine wave at all frequencies as specified below. A Bruel and Kjaer recorder, type 2304, with potentiometer (type 2347) suitably calibrated, or an equivalent device, may be used.

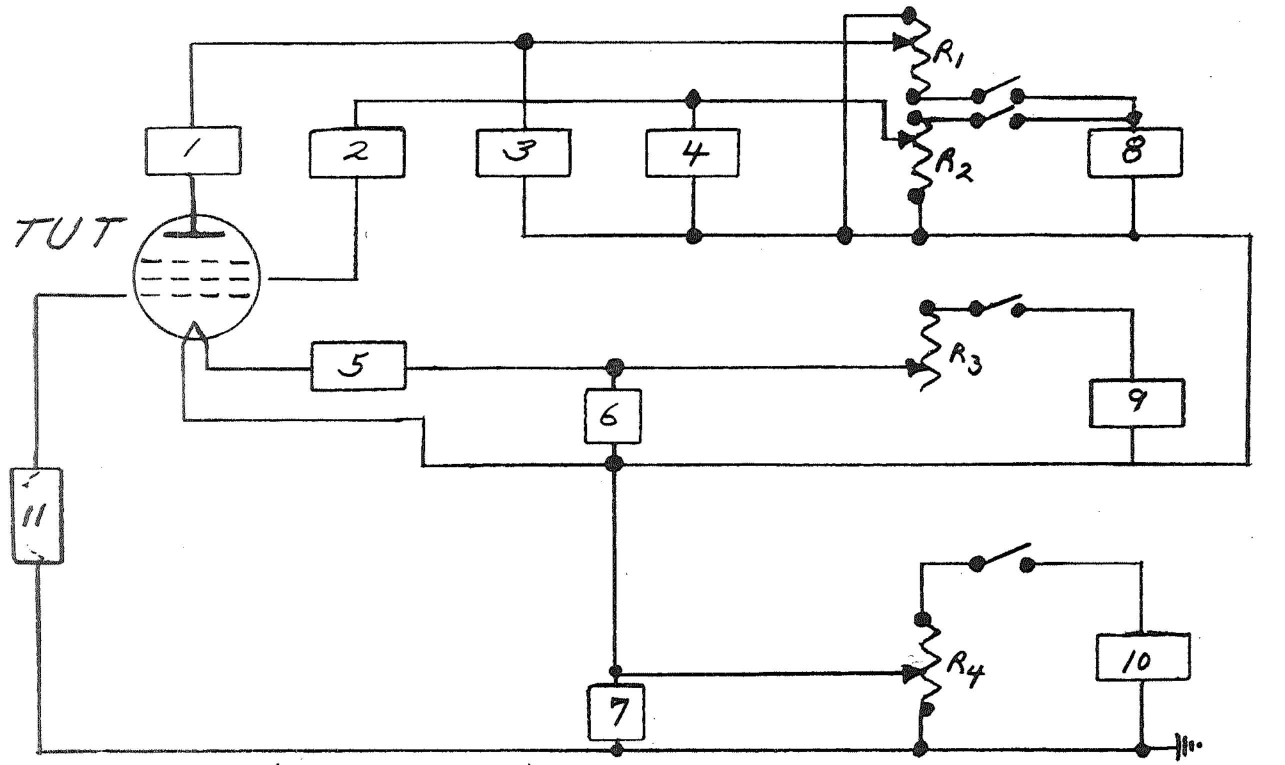
The voltage (ep) produced across the resistor (Rp) as a result of vibration shall be capacitance coupled to the measuring system consisting of cables, amplifier, low pass filter recorder. Input impedance of the measuring system shall have a minimum value of at least 10 times the resistor, Rp. Combined frequency response from the capacitor input through the amplifier and filter shall be flat within $\pm$ 1 db from 200 Hz to 10,000 Hz as referenced at 1000 Hz, shall be down 3 $\pm$1 db at 11,000 Hz, down 10 $\pm$ 1 db at 15,000 Hz and down 20 $\pm$1 db at 20 000 Hz. The impedance of the plate and screen voltage supplies shall not exceed that of a 40 uf capacitor at 10 Hz.

A high pass filter having an attenuation rate of 18 db/octave shall be set to filter out frequencies below 160 Hz. A maximum quiescent noise level with the tube under test voltages applied shall not exceed 0.3 millivolts.

NO.	DATE	BY	REVISION	DWN.			SCALE		RA[illegible]EON STANDARD ELECTROMETER
				CHK.			MAT'L.		TUBE GRID CURRENT TEST SET
				APPD			Q'TY.		

PLANT ENGINEERING DEPT.
RAYTHEON COMPANY, NEWTON, MASS.

ALL DIMENSIONS UNLESS OTHERWISE SPECIFIED MUST BE HELD TO A TOLERANCE. FRACTIONAL DIM. DEC. DIM.

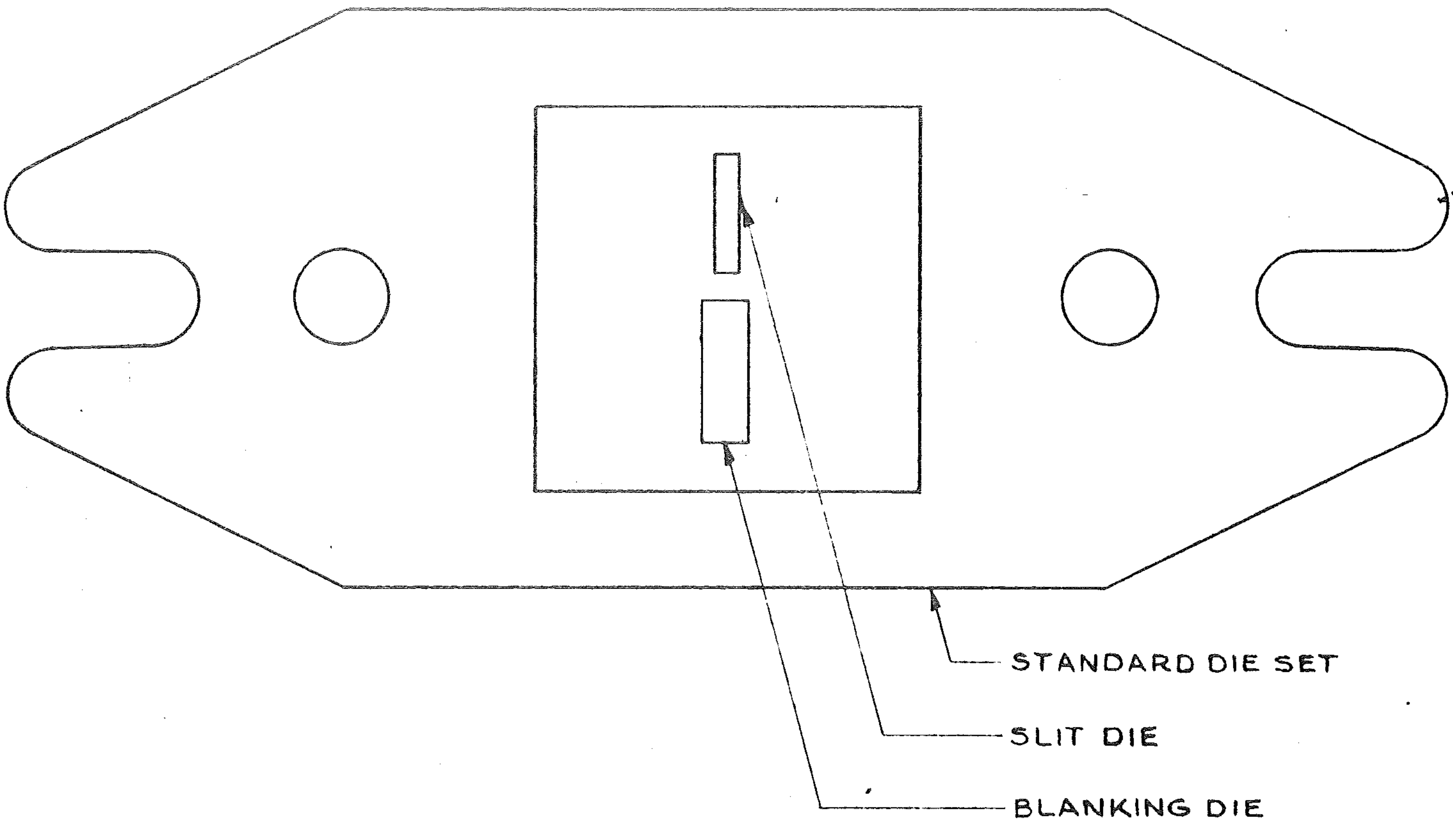


1. I_b Tri-Range (1000, 50, 10 μa) - Triplett 420 FS=10 μa
2. I_{c_2} 15 μa Range - Triplett 420 FS=10 μa
3. E_{bb} 15v Range - Triplett 420 FS=10 μa
4. E_{cc_2} Dual Range (10, 50v) - Triplett 420 FS-10 μa
5. I_f 0-15 ma Range - Triplett 420 FS=10 ma
6. E_f Dual Range (1.5, 7.5v) - Triplett 420 FS=10 μa
7. E_{c_1} 0-6v Range - Triplett 420 FS=10 μa
8. E_b & E_{c_2} supply Harrison Lab. 855B 0-18v
9. E_f supply Harrison Lab. 6204A-0-18v range
10. E_{c_1} supply Harrison Lab. 855B 0-18v
11. Cary Reed 31cv Electrometer input circuit 10^{12}, 10^{10}, 10^{8} ohm resistor ranges

R1. & R2. 10K ohm - 10 turn helical wirewound potentiometers.
R3. 100 ohm - 10 turn helical wirewound potentiometers.
R4. 2K ohm - 10 turn helical wirewound potentiometers.

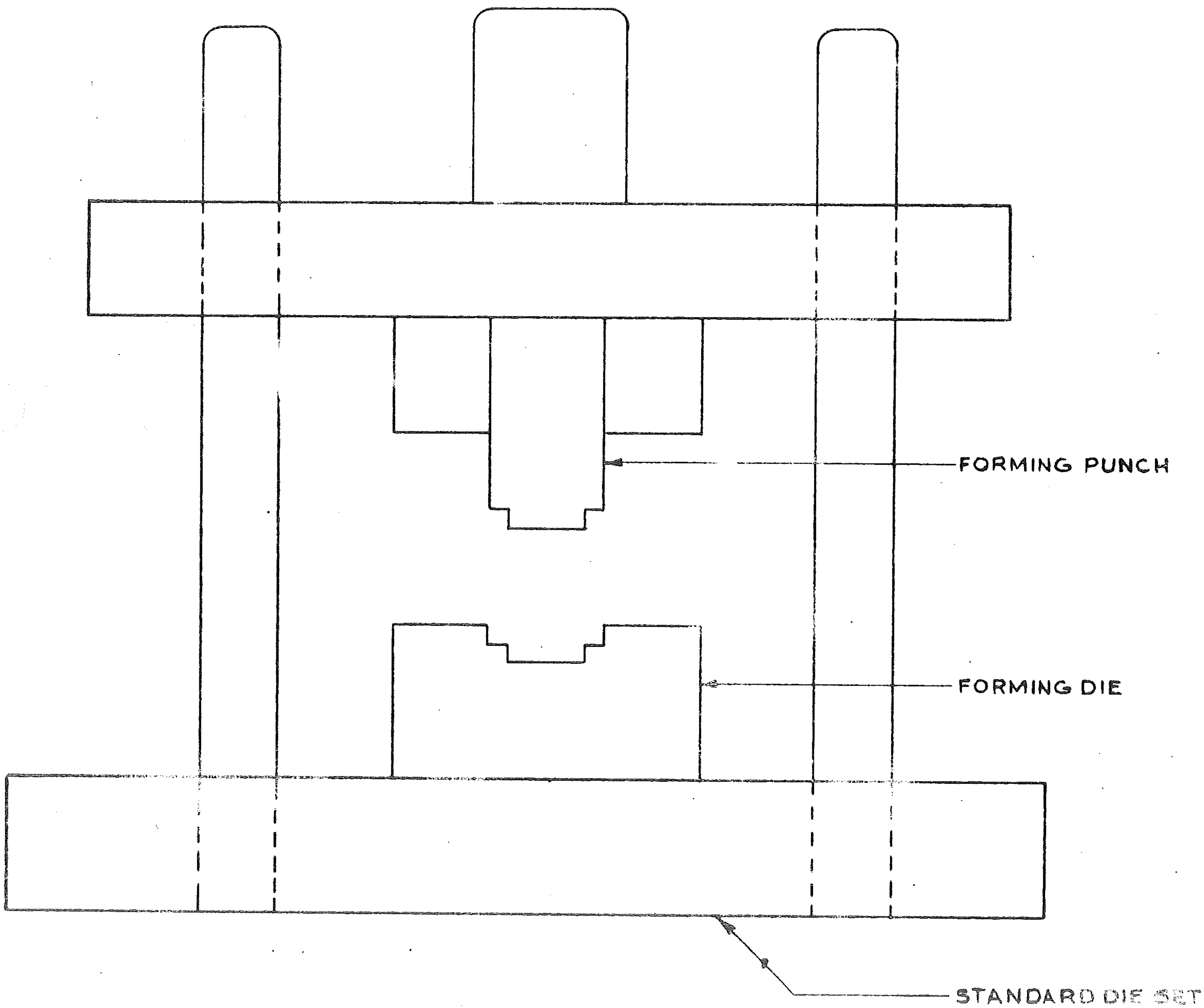
APPENDIX VI

JIGS & FIXTURES



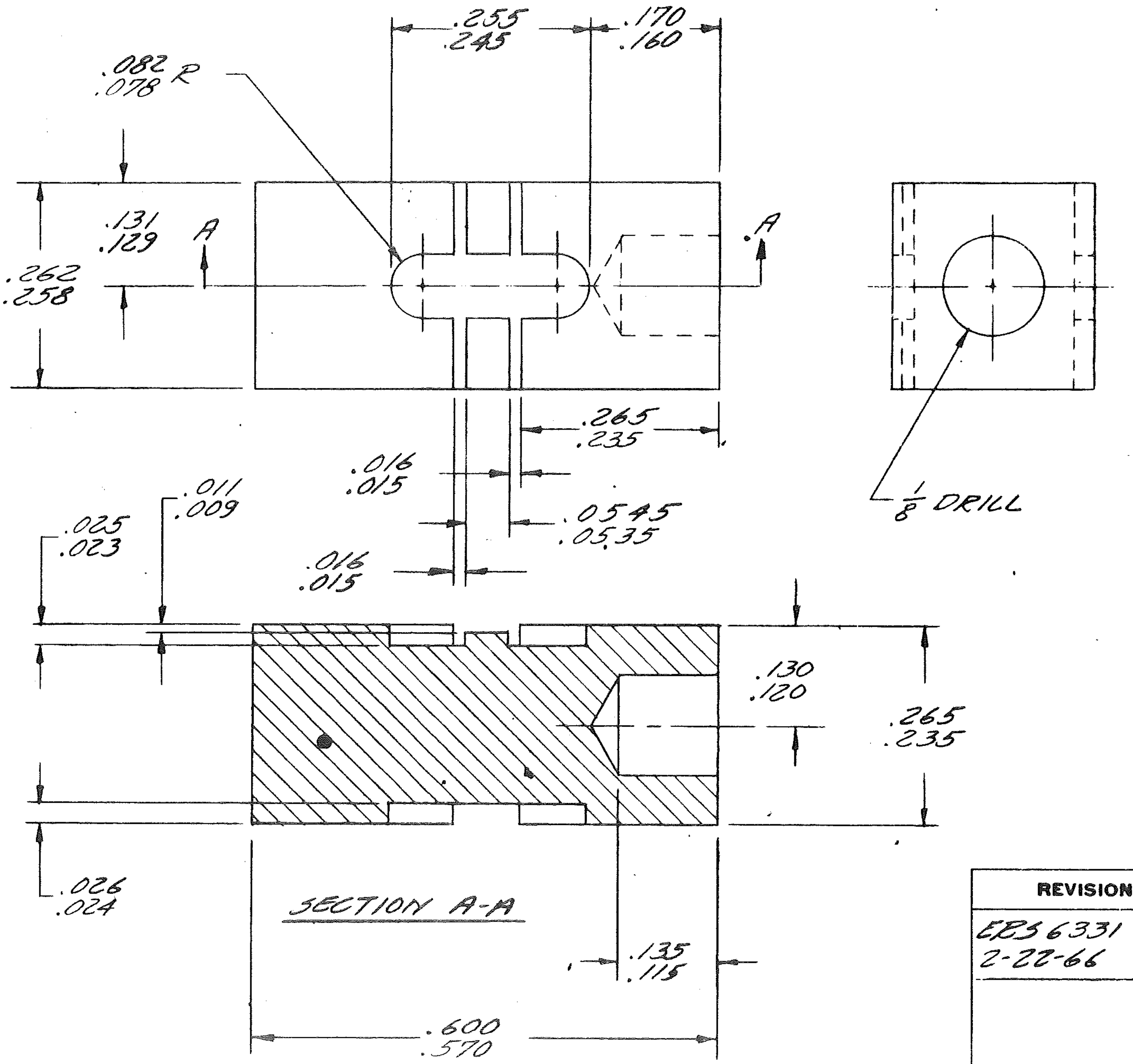
NOTE:
THIS SKETCH IS TO SHOW THE BASIC DIE WHICH WOULD HAVE A CORRESPONDING PUNCH (NOT SHOWN). DIMENSIONS ARE NOT SHOWN BECAUSE THEY WOULD VARY WITH THE STOCK THICKNESS AND PHYSICAL DIMENSIONS OF THE PART DESIRED.

NOTE:
THIS SKETCH IS TO SHOW THE BASIC FORMING PRINCIPLE USED. DIMENSIONS ARE NOT SHOWN BECAUSE THEY WOULD VARY WITH STOCK THICKNESS AND PHYSICAL DIMENSIONS OF PART DESIRED.



	RAYTHEON COMPANY INDUSTRIAL COMPONENTS DIVISION	26128	REV. 0
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED DIMENSIONS IN INCHES UNLESS NOTED DO NOT SCALE PRINT	WELDING JIG (OPEN FRAME GRID)	GROUP	QUANTITIES REQUIRED PER GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING
1	MALLORY OR COPPER	



CK 5886
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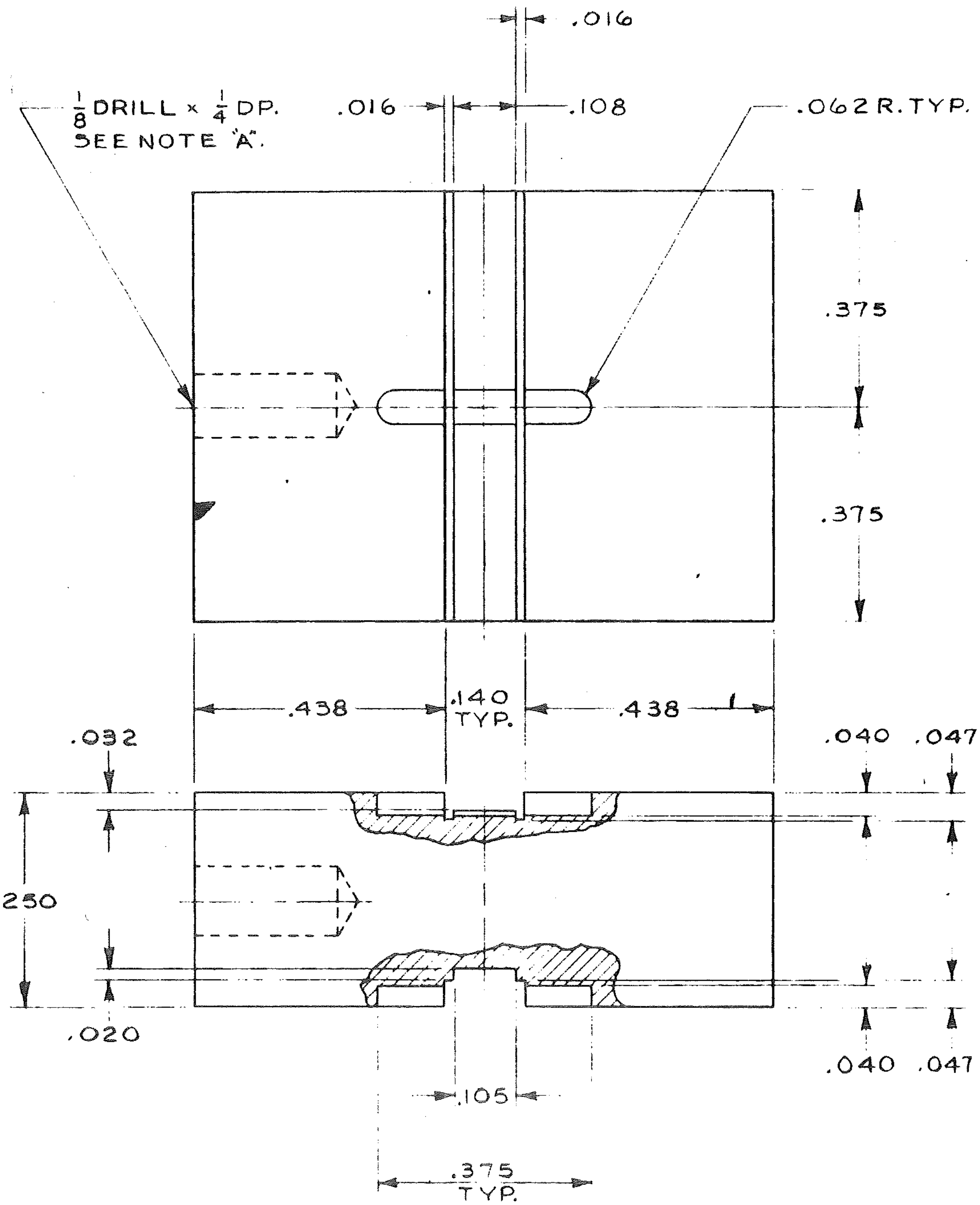
REVISIONS

ERS 6331 2-22-66	0

NOTE: SILVER SOLDER 2" LENGTH OF 1/8" DIA. MALLORY INTO 1/8 DIA. HOLE.

	RAYTHEON COMPANY **INDUSTRIAL COMPONENTS DIVISION**	A26257	REV. O
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED DIMENSIONS IN INCHES UNLESS NOTED DO NOT SCALE PRINT	WELDING JIG (#2 OPEN FRAME GRID)	GROUP	QUANTITIES REQUIRED PER GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING
1	COPPER	



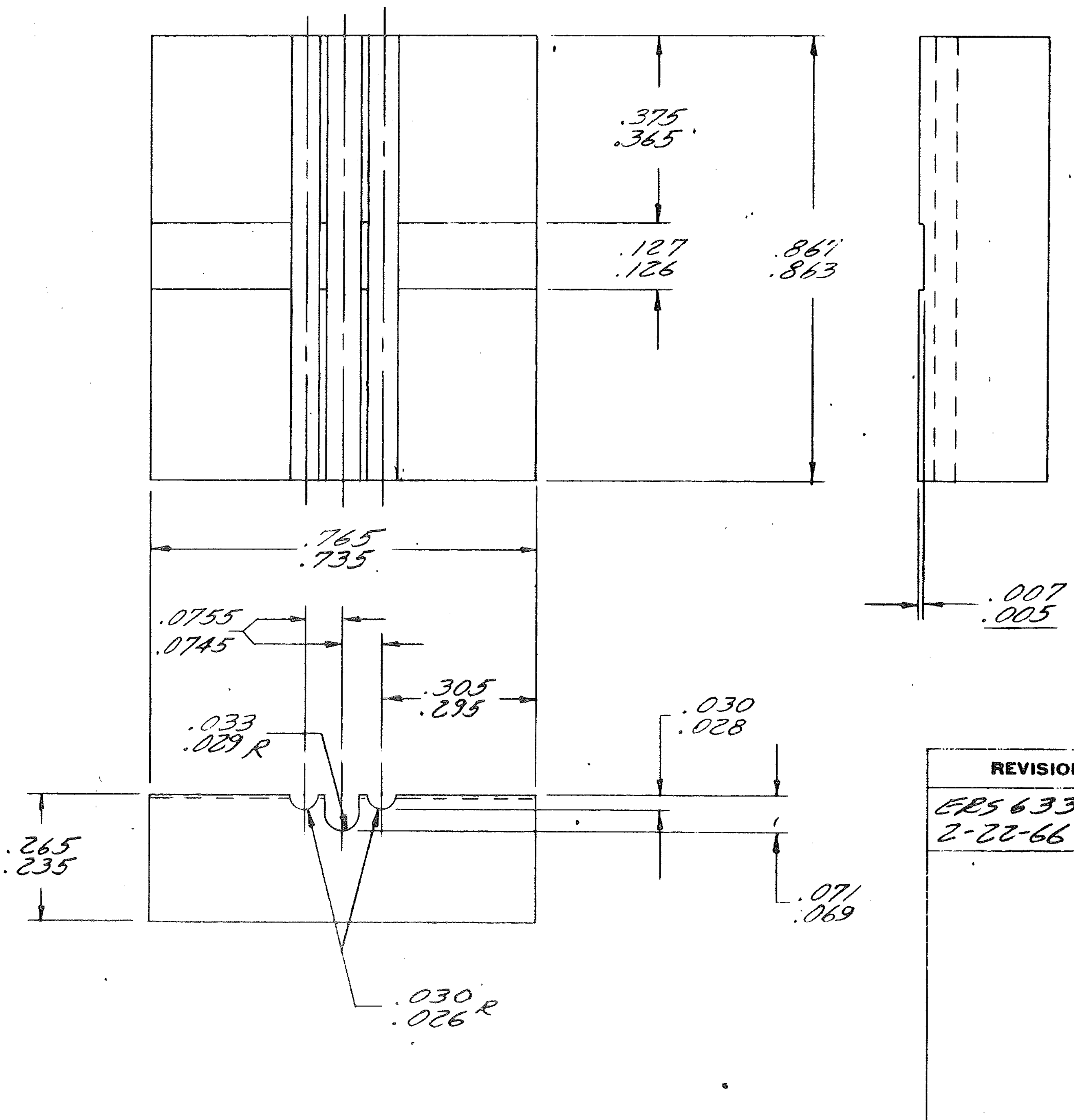
REVISIONS	
ERS 6384-3. R 10·4·66.	O

CK587

"A" SIZE SPECIFICAT. ORM NO. CM-48-TC 5-61

	RAYTHEON COMPANY INDUSTRIAL COMPONENTS DIVISION	26129 REV. 0
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED DIMENSIONS IN INCHES UNLESS NOTED DO NOT SCALE PRINT	WELDING JIG (CONTROL ELEMENT)	QUANTITIES REQUIRED PER GROUP GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING
1	MALLORY OR COPPER	
3	COLD ROLLED STEEL	



QV 293
QV 309

REVISIONS	
ERS 6331 2-22-66	0

"A" SIZE SPECIFICATION FORM NO. CH-48-TC 5-61

APPENDIX VII

ANALYSIS OF THE RESIDUAL GAS CONTENT OF EVACUATED GLASS ENVELOPES

Introduction

Three styles of glass bulbs, supplied by the Industrial Components Division under the shipping memo 9329 of J. A. Williams, have been analyzed as to gas content.

Style 1	T1 1/2 x 2 Bulb (Glass Type 0120) Evacuated on Raytheon System
Style 2	Same bulb pre-evacuated
Style 3	Bulb of different type glass Evacuated on Raytheon System

The results of four samples of each bulb style follow.

Experimental Apparatus & Technique

The exhaust tubulation of the pre-evacuated bulbs of Style 2 were shortened to about the length of the other bulbs. Then all bulbs were cleaned in Alconox, rinsed in deionized water and demineralized water.

Each sample, including those of Style 2, was scored with a clean file and broken into two pieces before mounting in the vacuum system. After obtaining a level background pressure, a sample is quickly dropped into a quartz tube kept in an electrically heated oven. 150°C was used for degassing all samples. The gases liberated upon heating a sample are pumped away through a calibrated orifice, while the instantaneous total and partial ion currents are measured and recorded by means of an ML-494 radio-frequency type mass spectrometer. Partial ion currents of the gas species of atomic mass values from 12 to 50 and 2 are determined by one minute automatic scanning of the appropriate radio-frequency range; allowing a sensibility of about one part in 1,000.

Results & Discussion

The maximum rate of liberation of gases is seen to occur at four to five minutes after the samples are dropped into the oven. This is probably more a function of heat-up time than diffusion rate of the gases in the glass. At no time were any mass values higher than 44 detected.

The degassing curves seem to be quite reproducible within the limits of uniformity of volume and surface area of glass for each of the three styles. For the first three samples of each style, no CO_2 was detected at mass 44, so the sensitivity of the measuring apparatus was increased for the fourth sample run of each bulb style. This results in higher ion currents for nearly all of the mass values, so that the fourth sample results must not be compared with those of the first three, except in the case of total pressure values.

The approximate sensitivities of the mass spectrometer are:

Gas	A. M. U.	Sensitivity
N_2	28	2.2×10^5 torr/amp
H_2O	18	6.5×10^4 torr/amp
H_2	2	1.3×10^4 torr/amp
CO_2	44	
Samples 1, 2, 3		4.2×10^6 torr/amp
Sample 4		7.6×10^5 torr/amp

Results & Discussion (continued)

Thus, it is clear that water at mass 18 is the major consituent of the gases released from all three styles of glass bulb, although it shows a quicker decline than the other major gas component, hydrogen. In reality, a small portion of the hydrogen detected is caused by the cracking of H_2O in the source of the spectrometer tube.

Mass 28 is frequently composed of the two gases N_2 and CO. However, the values at mass 14 (N) indicate that nearly all of the 28 ion current for bulb styles 1 and 3 is due to nitrogen desorption. The pre-evacuated bulbs of Style 2, on the other hand, have larger ratios of mass 28 to 14 indicating the presence of CO. Likewise, the pre-evacuated bulbs show the release of methane (rise in mass 15) which is apparently removed along with CO in the pumping process.

Mass 19 is believed due to the desorption of fluorine from the mass spectrometer tube and the glass walls of the vacuum system in general. Its admittance to the system has definitely been traced to a source other than the glass bulbs analyzed here. Mass 20 is HF. Mass 17 comes from the splitting of H_2O into H^+ and OH^-; the OH^- then being ionized to form OH^+. Mass 16 is oxygen. The fact that O_2 at mass 32 is not seen implies that mass 16 also is a by-product of other desorbed gases; e. g. , H_2O and CO. Carbon is shown at mass 12 and comes mostly from CO, hydrocarbons and the cathode of the mass spectrometer tube itself.

Conclusions

For a general picture of the degassing characteristics, the total pressure values at the start, peak rate of evolution, and after 60 minutes of degassing are grouped together in Table 1. Also, the mathematical integration of the total pressure at 7, 15, 30, and 60 minutes is shown and averaged for each bulb style. This shows not only the effectiveness of pumping bulb style 1 (compare styles 1 and 2), but also the possible advantages of changing to style 3.

Style 3 shows very little more gas than 1, but it is found to have two and a half times the mass of style 1, so that it has less gas per unit mass. It also has a considerably larger sealed off volume, therefore permitting the walls and internal components to desorb more gas after pinch-off to effect the same amount of pressure rise as would occur with bulb style 1.

TABLE I
DEGAS ANALYSIS OF GLASS BULBS

Summation of total pressure values taken at one minute intervals in arbitrary units for comparative evaluation only.

SAMPLE		TOTAL PRESSURE: TORR			SUMMATION PRESSURE			
Bulb Style	Sample No.	Start	Peak	60 Min.	7 Min.	15 Min.	30 Min.	60 Min.
1	1	$3.7x10^{-7}$	$3.8x10^{-6}$	$7.0x10^{-7}$	1.7	3.1	4.6	7.0
	2	$3.5x10^{-7}$	$2.4x10^{-6}$	$7.2x10^{-7}$	1.2	2.3	3.8	6.1
	3	$2.6x10^{-7}$	$1.9x10^{-6}$	$4.1x10^{-7}$	0.87	1.7	2.7	4.1
	4	$3.4x10^{-7}$	$2.0x10^{-6}$	$5.8x10^{-7}$	0.96	2.0	3.2	5.1
Average		$3.3x10^{-7}$	$2.5x10^{-6}$	$6.0x10^{-7}$	1.2	2.3	3.6	5.6
2	1	$4.0x10^{-7}$	$1.7x10^{-5}$	$9.4x10^{-7}$	7.4	12	14	18
	2	$3.6x10^{-7}$	$1.3x10^{-5}$	$9.6x10^{-7}$	5.5	8.5	12	16
	3	$2.7x10^{-7}$	$7.6x10^{-6}$	$7.4x10^{-7}$	3.3	5.9	7.0	12
	4	$3.7x10^{-7}$	$1.1x10^{-5}$	$7.8x10^{-7}$	4.8	8.1	10	13
Average		$3.5x10^{-7}$	$1.2x10^{-5}$	$8.5x10^{-7}$	5.2	8.6	11	15
3	1	$3.6x10^{-7}$	$3.8x10^{-6}$	$5.6x10^{-7}$	1.6	3.3	4.7	7.4
	2	$3.4x10^{-7}$	$2.5x10^{-6}$	$5.5x10^{-7}$	1.1	2.0	3.2	5.1
	3	$2.6x10^{-7}$	$2.4x10^{-6}$	$4.7x10^{-7}$	1.0	2.2	3.3	4.9
Average		$3.2x10^{-7}$	$2.9x10^{-6}$	$5.3x10^{-7}$	1.2	2.5	3.8	5.8

APPENDIX VIII

CONTACT POTENTIAL MEASUREMENT

Grid current characteristic curves obtained with the tube functioning under normal operating conditions can be used to form a good picture of the true contact potential for any given tube.

These are retarding potential measurements, and because they lie well below the tube saturation region, they may be measured at normal cathode temperature without damage to the tube. In this process it is necessary to apply a negative voltage to the grid to retard the majority of the available electrons. The grid curve will vary with changes in grid and cathode work function, but in good electrometer tubes, will vary only very slightly due to leakage currents and grid emission.

Because the work functions of materials are effected by their temperature, it was decided that this method of determining contact potential, with the filament hot, would be used during the contract. Control grid current curves were taken with normal plate and screen voltages applied which is opposite to the classic method of grounding or floating these elements. However, because we are concerned with good electrometer tubes, the voltages and currents involved are very low, causing little shift due to gas ions or increased leakage.

Retarding potentials measured under these conditions provide an indication of bias shifts due to all causes, but in electrometer tubes the causes of bias shift other than those of contact potential and initial velocity appear to be negligible; and most of these causes can be eliminated by the method of projection intersection of the log slope part of the grid curve with the zero grid current line. Reading the grid bias voltage at this point appears to provide the best indication of the true contact potential for an electrometer tube while it is in operation.

REFERENCES

For more detailed discussions on the overall subject of Contact Potential (some of which may be applicable to the electrometer tube) one can refer to the following articles:

1. Bowie, R. M. "This Matter Of Contact Potential" Proc. IRE Vol. 24, Page 1501 (1936)
2. McCormack, R. L. & Wood, R. - Raytheon Technical & Information Bulletin - Number 7. (1944)
3. Patai, F. & Pomerante, M. A., "Contact Potential Differences" Journal Franklyn Institute Vol. 26, Pages 17-19. (1955).
4. Schrader, E. R., "A Survey Of Methods Used To Determine Contact Potentials In Receiving Tubes" RCA Review, Pages 243-254, (1957).

APPENDIX IX

The Development Of A Low Drain Filamentary Metal Ceramic Electrometer Tube

The development of a low drain filamentary metal ceramic electrometer tube was perhaps the most difficult and involved task undertaken during this contract. It is hoped that the following summary will describe more fully the many facets of this program.

The first task involved the design specifications of a 99+% alumina ceramic insulator with extremely tight tolerances, to be used for the basic support of the various tube elements. Prints were immediately forwarded to Coors Ceramic Company for feasibility studies and price information. Design drawings for all the remaining parts necessary to produce finished tubes were completed and a parts list with drawings of each individual part was published.

At this point, all of the parts designed were either ordered from outside vendors or work was begun to produce them in-house. As soon as all the parts were available, experimental work was begun at Raytheon to metallize and copper plate the top spacer to provide a means of anchoring this spacer to the top nickel sleeve as shown in print 49956, Appendix X. During this brazing operation, the tube elements were also to be anchored to the same top spacer. Efforts were directed at this time toward producing a leak tight metal ceramic header composed of a 99+% alumina spacer, a bottom nickel sleeve and seven flexible leads. The following is a brief description of the standard procedure for accomplishing this type of metal ceramic seal, and experimental variations thereof.

Using 99+% Alumina Ceramic Wafers

Group I

Test #1	Test #2	Test #3
Metallize with 75% 1-C Solution	Metallize with 50/50 1-C Solution	Metallize with 75% 1-C Solution. Fire at 1600°C for two cycles. Third cycle regular 1200°C firing.

All samples were copper flashed and nickel plated and flowed at 1200°C for 20 minutes. Assemblies were fabricated using nickel leads and cans and brazed with Cusil at 1650°F for twenty minutes. Veeco check - all samples were leakers, with the metallizing peeling off.

Group II

Test #1

Metallized with regular 75% Raytheon 1-C solution.

Test #2

Metallized with Lithium Molybdate solution.

Copper plate all samples. Fabricate assemblies with Dumet leads and Cusil brazing material. All samples leaked at the leads (Dye Check), with a poor bond at all surfaces.

Group III

Test #1

Metallized with 75% Raytheon 1-C solution containing 2% Titanium-Hydride by weight. Copper plate samples and flow copper. Fabricate assemblies with copper plated nickel cans and leads. Cusil braze. Samples leaked at the leads, but cans appeared to be well bonded.

Group IV

Test #1

Regular Wash

Test #2

Wash 15 minutes in hot chromic acid plus Metallex wash.

Metallize all samples using 75% 1-C solution plus 2% TiH_2 by weight. Copper plate all samples and flow copper. Fabricate assemblies with nickel leads and cans. Cusil braze. All samples leaked; poor bond in all areas.

Group V

Metallize with 75% Raytheon 1-C solution plus 2% TiH_2. Copper plate. Assemble with dumet leads Cusil braze. All samples leaked through lead seals.

Group VI

Standard cleaning and firing of ceramics. Direct metallizing and brazing of ceramic to metal using silver-manganese braze (85% Ag-15% Mn. Fire at 1200°C in dry hydrogen furnace. Poor wetting of metal to ceramic. Bond excellent where wetting took place.

Group VII

Standard metallizing and plating. Assemble with nickel leads and cans. Braze with silver manganese at 1200°C in dry hydrogen. Cans showed very good bonds to the ceramics. Leaks around the leads - AgMn did not appear to wet the holes.

Group VIII

Metallized with 75% Raytheon 1-C solution plus 2% TiH_2. Assembled with nickel cans and Dumet leads. Brazed with AgMn at 1200°C in a dry hydrogen furnace. All samples leaked around the leads.

Group IX

Test #1

Metallized with 75% 1-C solution.

Test #2

Metallized with 75% 1-C solution plus 2% TiH_2.

Assemblies were fabricated with nickel cans and Kovar leads. Brazing was performed with AgMn at 1200°C in a dry hydrogen furnace. The cans bonded well but one lead in each header appeared to have poor brazing causing a leak along the lead.

Group X

All samples were metallized with 94% tungsten, 5% manganese, and 1% iron oxide metallizing paint. The oxides were milled in a nitro-cellulose binder 20-40 hours before use.

Test #1

Metallizing painted on and pushed into holes.

Test #2

Parts were dipped into the paint which was blown into the holes.

The binder was burned out for 40 minutes and the metallized ceramics were then fired at 1160°C in wet hydrogen for 30 minutes. Cooling was accomplished as usual over a 20 minute period. The metallizing peeled in the holes and did not wet the ceramic. Waltham personnel, engaged in this work, felt that holes this small could not be successfully metallized with this type of paint and binder combination.

Using 96% Alumina Ceramic Wafers

Group I

All samples had the standard metallizing using 75% Raytheon 1-C solution. The spacers were copper plated and the copper flowed. Assemblies were fabricated with nickel cans and leads and brazed with Cusil. All the samples leaked and appeared to be identical to the 99+% alumina samples.

Group II

Standard cleaning - all samples.

Test #1	Test #2
1 cycle metallizing copper plated and flowed.	2 cycle metallizing copper plated and flowed.

Combinations of copper and Dumet leads were tried in each test with both copper and Cusil brazing. The Cusil was brazed at 1650°F and the copper at 1200°C. All samples leaked as before; the bonds between the metallizing and the ceramics were poor.

Group III

Ceramics were given to a production operator who normally prepares the 96% alumina ceramics in regular use. The operator metallized them using the following production schedule.

1) Wash in Calgonite for twenty minutes and dry.
2) Air fire one hour.
3) Metallize - soak ten minutes in 75% Raytheon 1-C solution. Blow off excess and fire at 1200°C for ten minutes. Cool as in standard procedure.
4) Copper plate and flow copper.

Test #1	Test #2
Assemble nickel cans and leads Copper braze at 1200°C.	Assemble nickel cans and Dumet leads. Copper braze at 1200°C.

All samples leaked by the leads and there was little evidence of bonding between the metallizing and the ceramic. Samples were sent to the Chemical Laboratory for sectioning and polishing. Using 500X amplification, there was no evidence of glass formation at the metal-ceramic interface.

Group IV

This test was designed to form a glassy phase at the surface of the ceramic by air firing the ceramic after soaking it in Raytheon 1-C solution. After cleaning and firing the ceramics, they were soaked in 75% Raytheon 1-C solution for 10 minutes and the excess was blown off with filtered air.

The ceramics were then air fired at 900°C for 1 hour and metallized using the standard procedure, after which they were copper plated and the copper was flowed. Severe cracking of the ceramic was visible in all samples when the surfaces were ground off prior to assembly. This was a good indication that glass was formed, but that the mismatch between the ceramic and the glassy phase was too great.

Work Carried Out By The Waltham Ceramics Department

The following three attempts were carried out by the Waltham Ceramics Engineers using the Waltham facilities:

Group I

Ceramics were high fired at 1650°C to produce a small amount of glass at the surface of the ceramic. The pieces were metallized by the standard procedure. The results were still negative with no apparent bond between the metallizing and the ceramic.

Group II

The countersink around the holes in the ceramics were enlarged, and all the pieces were metallized using Walthams' spray technique and Molybdenum-titanium metallizing. These samples were then Cusil brazed at the Quincy facilities. The results were still negative, being the same as for Group I above.

Group III

This was an attempt to metallize the flat surfaces of the ceramics and braze on a metal washer that could be crosscut to provide an insulating surface between the leads. The metallizing was Walthams' Moly-Ti tape. The results were again negative as the washer peeled off, apparently a good bond was still lacking between the washers and the metallizing. The conclusion of the Waltham Ceramic Department was that this ceramic would not form a glassy phase using their established manufacturing methods.

Unsuccessful attempts to produce leak-tight metal ceramic headers at Raytheon led to the establishing of a parallel effort at Coors Ceramic Company in Colorado to take advantage of their knowledge and ability in the ceramics field.

99+% alumina spacers plus the necessary metal parts were forwarded to Coors for this effort. When all attempts using standard parts were unsuccessful, Coors requested that the lead hole size be increased from .017"-.020" to .021" ± .0015". This attempt was also unsuccessful, and an additional request to change from nickel to copper plating was granted. At this point 96% alumina spacers were ordered.

When Coors was still unable to produce leak-tight headers using 99+% alumina and copper plating, the decision was made by Raytheon personnel and the NASA Technical Officer to go over entirely to the 96% alumina. Therefore, the necessary components to produce fifty (50) leak-tight headers using 96% alumina spacers were dispatched to Coors. An order was undertaken by Coors on a best efforts basis and subsequently forty (40) completed samples were delivered to Raytheon. All forty (40) samples proved unsatisfactory with leaks around the stem leads. A series of telephone calls to Coors resulted in an exchange of ideas between Raytheon and Coors engineers.

Coors engineering indicated that all the available parts had been used in the one run that resulted in the defective header noted above. Coors felt that a further best efforts program should be carried out to investigate other techniques, such as the vacuum chuck method of metallizing. Two (2) other methods to be tried would be mechanical and acid cleaning of the ceramic wafer to insure that iron particles deposited by the press at forming would be completely removed. A best efforts purchase order, having the following stipulations, was placed with Coors.

1. Raytheon to supply Coors with all parts necessary to fabricate fifty (50) metal ceramic headers.

2. Coors to use three (3) ceramics per test, employing the three experimental methods discussed by telephone, with a repeat of three more ceramics using the most promising method.

3. Coors to notify Raytheon of progress at this point before initiating further tests.

4. Testing to continue on this basis until the fifty parts supplied by Raytheon were used up, or a vacuum tight header developed.

Finally, on December 1, 1965 the NASA Technical Officer notified Raytheon that Coors had succeeded in making leak-tight headers using lithium-molydbate metallizing and silver braze. Raytheon contacted Coors and was further notified that they (Coors) had also produced three (3) leak-tight headers using moly-manganese metallizing. Raytheon authorized Coors to produce twelve (12) samples per each of the two methods employed. In a follow-up call, Coors reported that they had produced twelve samples using each of the two methods outlined below.

1. 96% alumina ceramics, lithium-molydate metallizing, nickel flash and pure silver braze.

2. 96% alumina ceramics, moly-manganese metallizing (utilizing vacuum chuck), nickel plate and sinter, pure silver braze.

Although all twenty-four (24) samples were leak-tight, there was a problem of bridging over between the leads and the nickel shell caused by the brazing material. Coors agreed to inspect each header and mark the ones they considered good. On the basis of destructive tests performed at Coors, the engineers there expressed a preference for lithium-molybdate metallizing.

However, this method necessitates the removal of .003" stock from each side of the ceramic after metallizing, in order to maintain the integrity of the dielectric constant of the ceramic. Raytheon agreed to accept the twenty-four samples with all pertinent data. In a later quote, Coors Porcelain Company expressed a willingness to provide leak-tight headers in both 96% and 99+% alumina using a lithium-molydate metallizing and pure silver braze.

As soon as the leak-tight headers were received, samples were heli-arc welded to form complete metal ceramic envelopes without the actual tube inside and evacuated on the Varian Vac-Ion pumping system. The ambient temperature was cycled from room temperature to 500°C in five steps. Samples were subjected to one hour at each successive temperature and then cooled. At the end of each cycle the resistance readings between all the leads and the outside metal cans were recorded. After exposure to the 500°C temperature a 48 hour stabilization period before testing was necessary. For each sample tested, the resistance readings were higher than 5×10^{15} ohms.

Attempts to heli-arc weld headers and cans together to form leak-tight assemblies for thermal cycling on the Varian, made it clear that because of the geometry of the structure, the conventional flow of protective atmosphere around the arc did not protect the inside surface of the copper exhaust tubing - resulting in the production of copper oxide which degraded the seal. A method was worked out to provide supplemental internal flushing with argon to protect internal surfaces during welding.

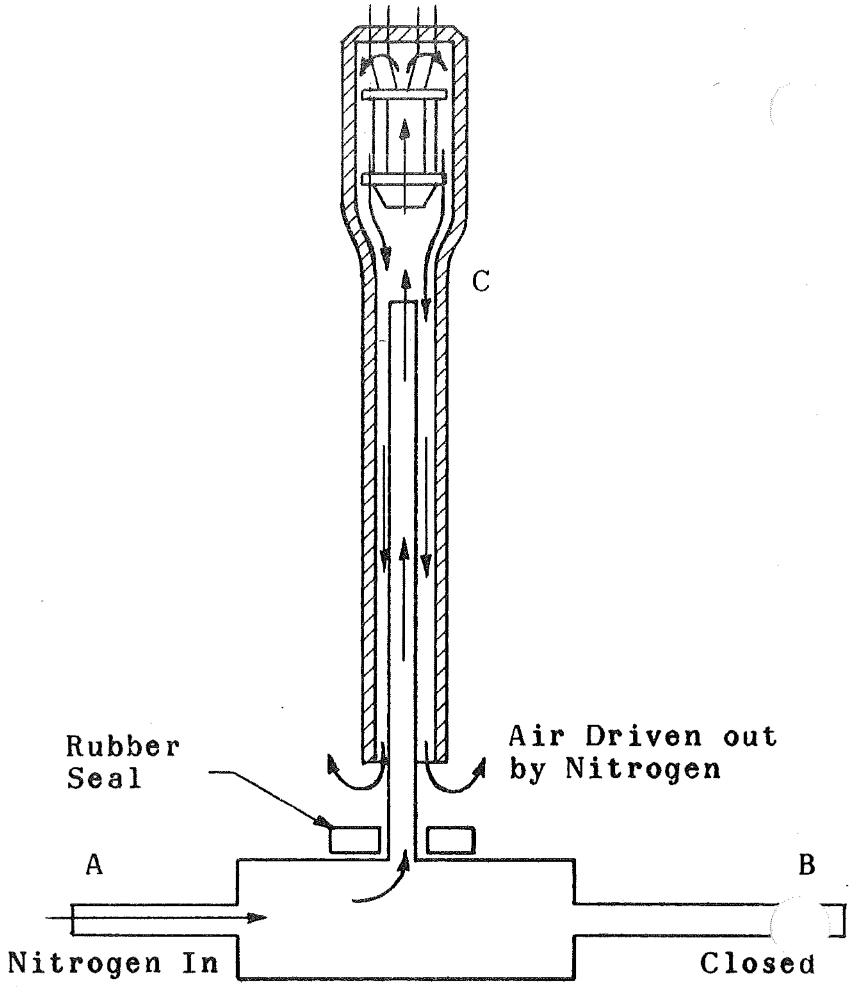
At this time, experiments performed using a Raytheon Ultrasonic Impact Grinder provided a method of thinning the ceramics to a few thousandths of an inch in the area where the filament and the ceramics normally make contact. It is known that ceramics have a much greater cooling effect on filament temperature than the mica spacers in regular use. Therefore, a small contact area between the filament and each of the two ceramics used to support the tube elements is felt to be very desirable.

Making use of the new techniques developed, and the availability of all necessary parts, preliminary QV291 samples were fabricated and processed. Although much remains to be done to improve the electrical characteristics of these tubes, it is felt that a very important point in the development of a filamentary metal-ceramic electrometer tube has now been reached.

APPENDIX X

ILLUSTRATIONS

IMPROVED METHOD OF CRITICAL BULB TO MICA CRIMPING



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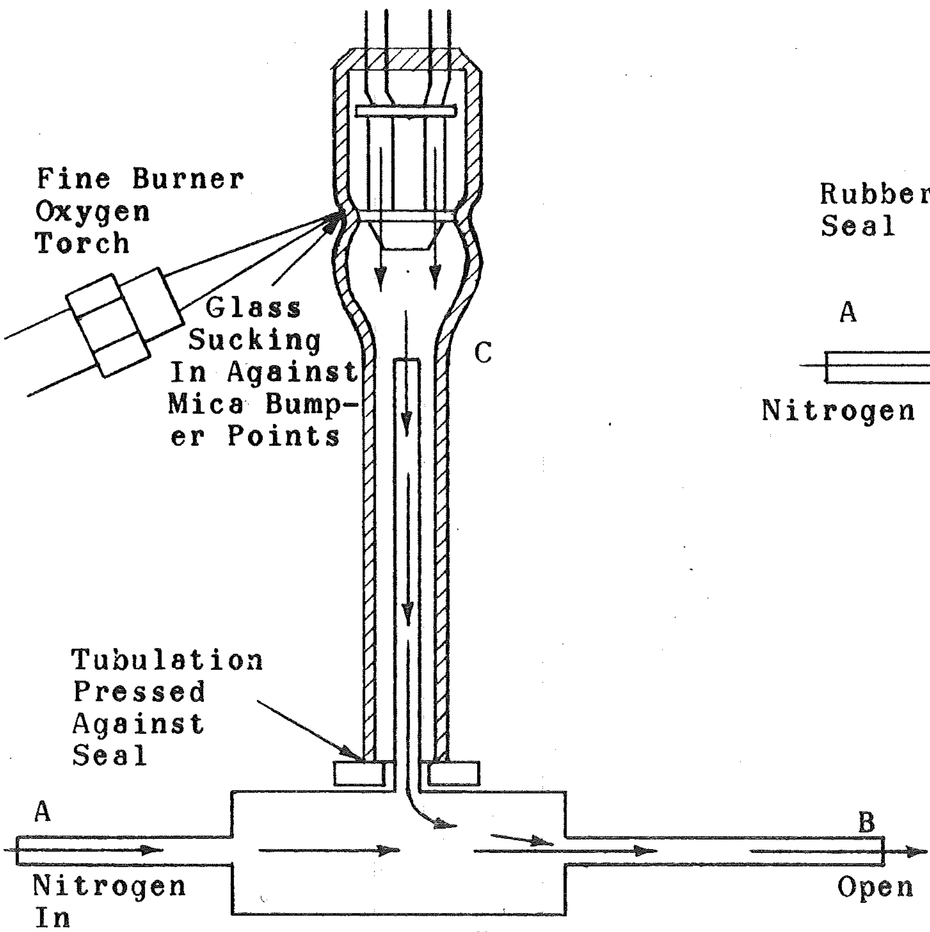


POSITION #2

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

A26076 — REV. 0

DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED

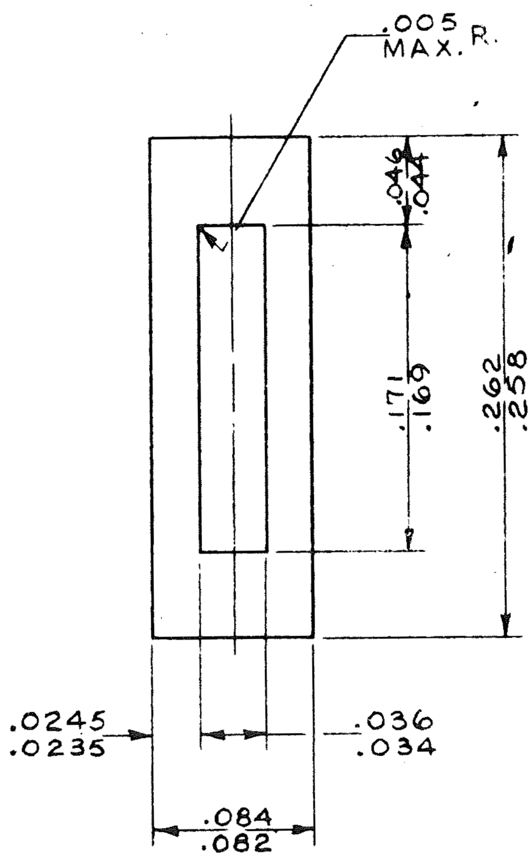
DIMENSIONS IN INCHES UNLESS NOTED
DO NOT SCALE PRINT

FACE PLATE (OPEN FRAME GRID)

QUANTITIES REQUIRED PER GROUP

GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING
1	.004 THICK FULL HARD NICKEL	



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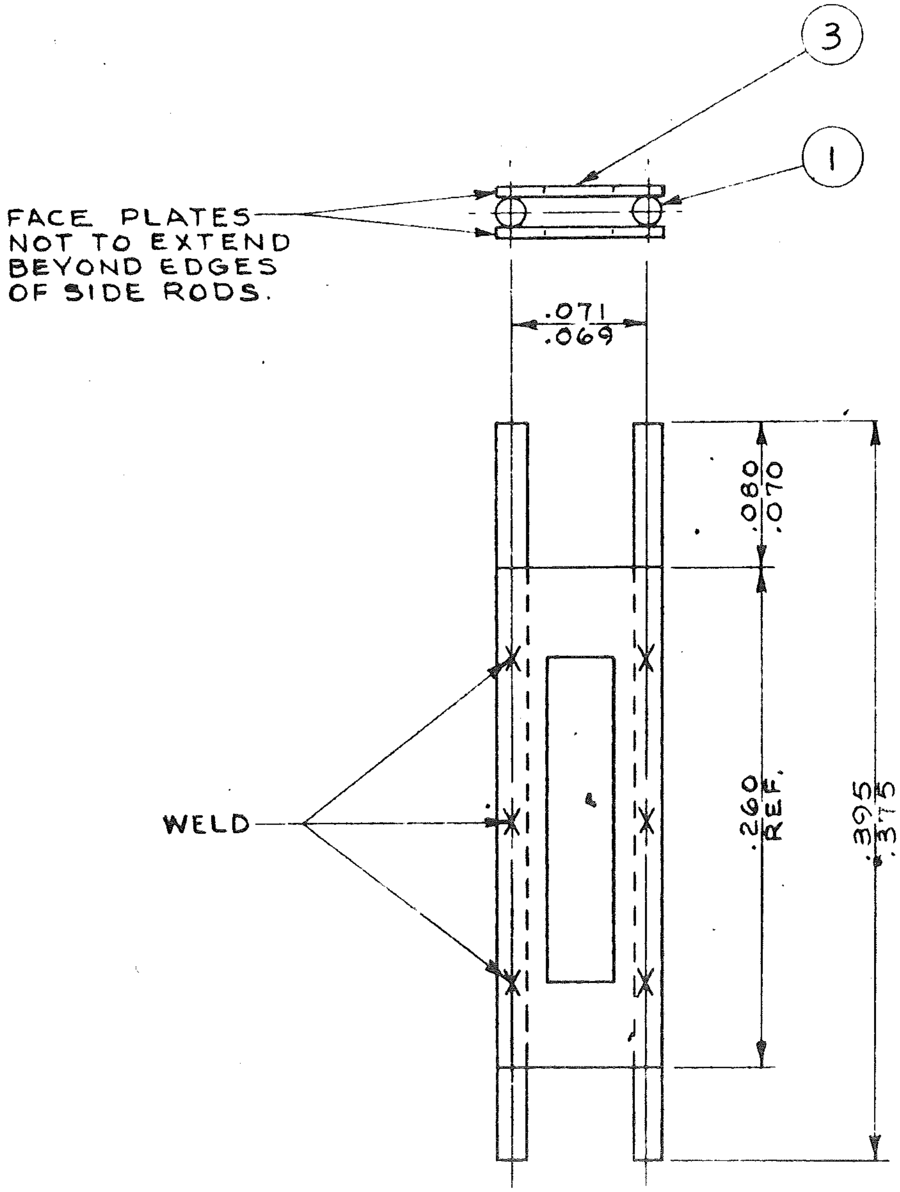
ERS 6318. R 12-3-65.	0

"A" SIZE SPECIFICAT... ORM NO. CM-48-TC 8-61

	RAYTHEON COMPANY INDUSTRIAL COMPONENTS DIVISION	A26077 — REV. 1
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED DIMENSIONS IN INCHES UNLESS NOTED DO NOT SCALE PRINT	GRID ASSEMBLY (OPEN FRAME GRID)	QUANTITIES REQUIRED PER GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING	GROUP 2				
1	SIDE ROD	A26075-1	2				
3	FACE PLATE	A26076-1	2				



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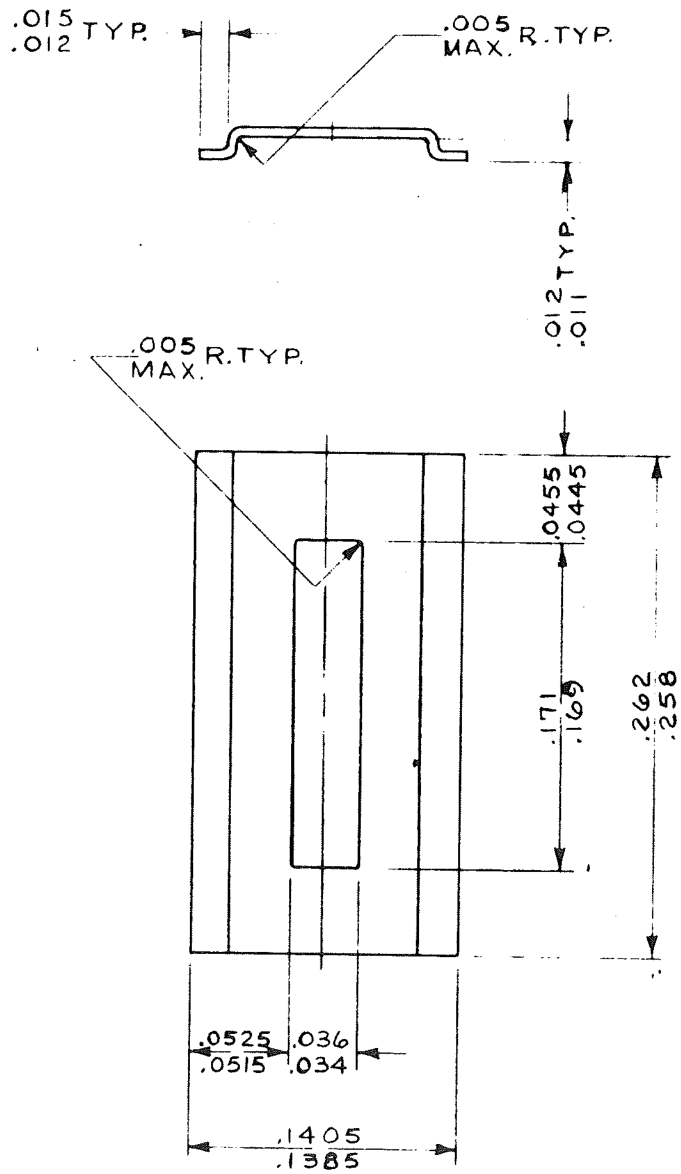
A. - APERTURES TO BE ALIGNED WITHIN ±.0005.

"A" SIZE SPECIFICATION FORM NO. CM-48-TC 3-61

	RAYTHEON COMPANY **INDUSTRIAL COMPONENTS DIVISION**	A26254 REV. O
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED DIMENSIONS IN INCHES UNLESS NOTED DO NOT SCALE PRINT	FACE PLATE (OPEN FRAME GRID)	GROUP / QUANTITIES REQUIRED PER GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING
1	.004 THICK FULL HARD NICKEL	



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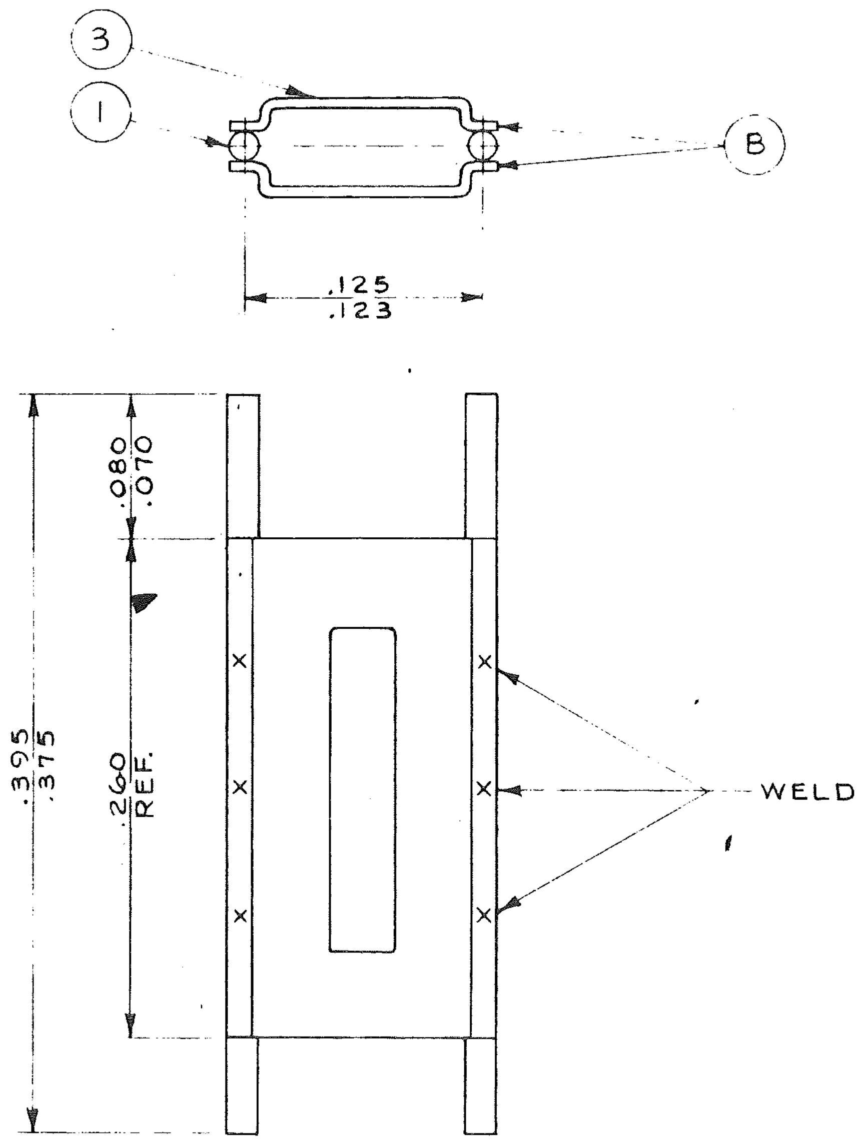
REVISIONS	
ERS6384-2. F 10·4·66.	O

"A" SIZE SPECIFICA... FORM NO. CM-48-TC 5-61

	RAYTHEON COMPANY **INDUSTRIAL COMPONENTS DIVISION**	A26255	REV 0
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED DIMENSIONS IN INCHES UNLESS NOTED DO NOT SCALE PRINT	GRID ASSEMBLY (OPEN FRAME GRID)	QUANTITIES REQUIRED PER GROUP	

ITEM	BILL OF MATERIAL	REFERENCE DRAWING	GROUP 2				
1	SIDE ROD	A26075-P1	2				
3	FACE PLATE	A26254-P1	2				



NOTES:
A. - APERTURES TO BE ALIGNED WITHIN ±.001.
B. - FACE PLATES NOT TO EXTEND BEYOND EDGES OF SIDE RODS.

REVISIONS	
ERS6384-1. R 10·4·66.	0

CK587

"A" SIZE SPECIFICATION FORM NO. CM-48-TC 5-61

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

26121 REV. 0

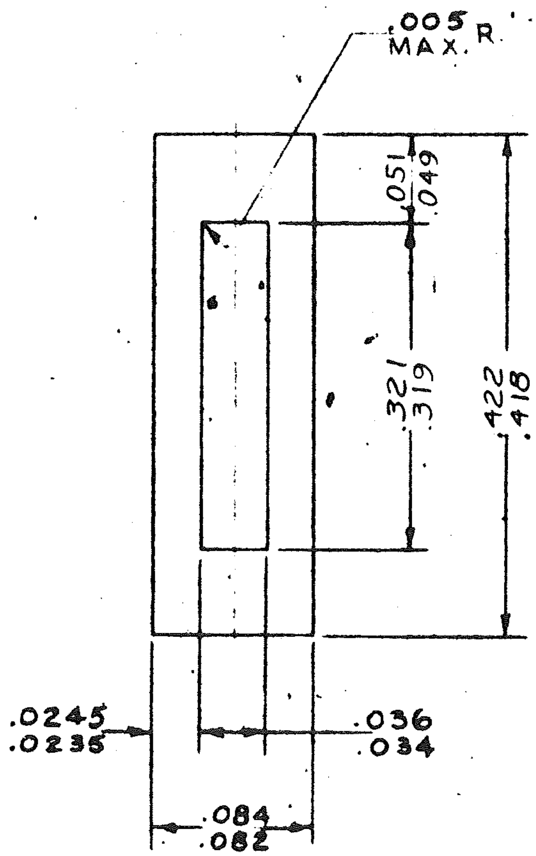
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED

DIMENSIONS IN INCHES UNLESS NOTED
DO NOT SCALE PRINT

FACE PLATE (OPEN FRAME GRID)

QUANTITIES REQUIRED PER GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING	GROUP
1	.004 THICK FULL HARD NICKEL		



REVISIONS	
ERS 6322	
1-10-66	0

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

26123 REV. 0

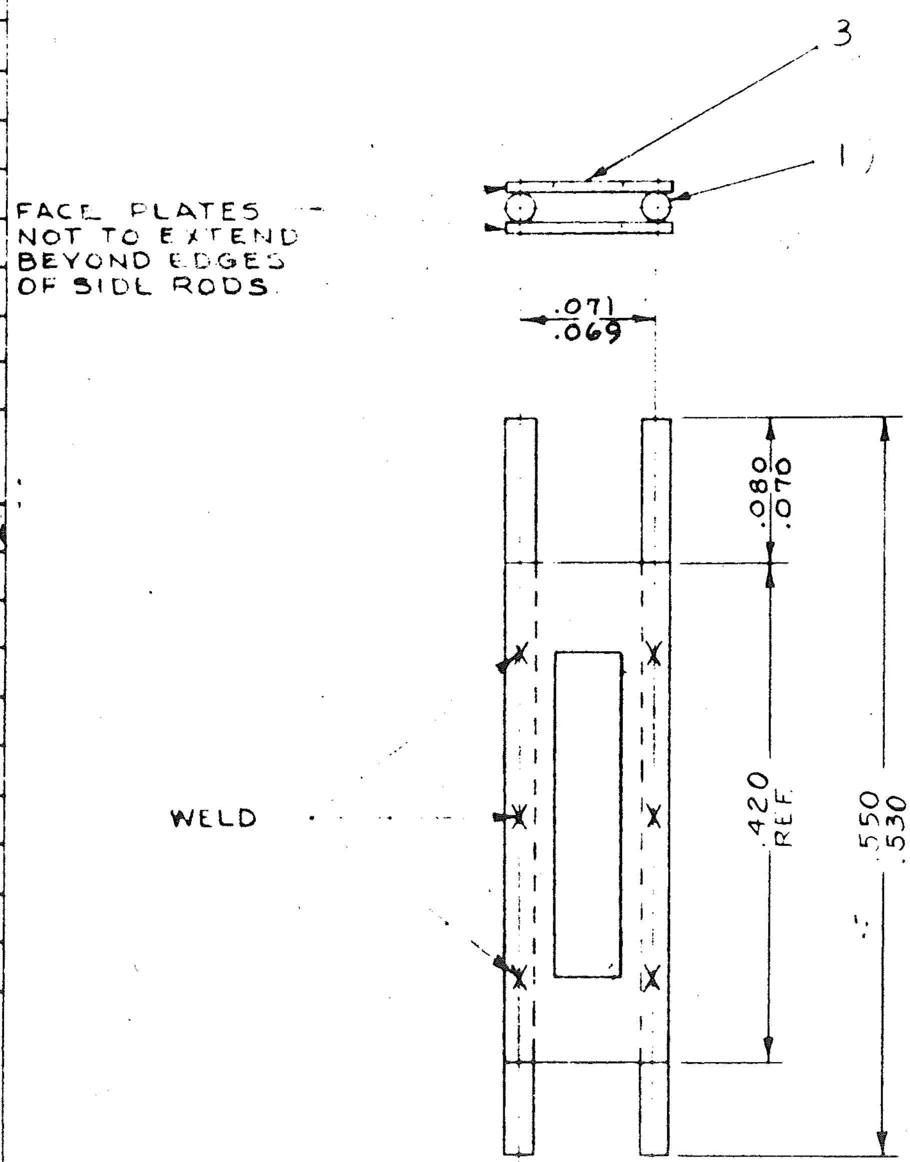
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED

DIMENSIONS IN INCHES UNLESS NOTED
DO NOT SCALE PRINT

GRID ASSEMBLY
(OPEN FRAME GRID)

QUANTITIES REQUIRED PER GROUP

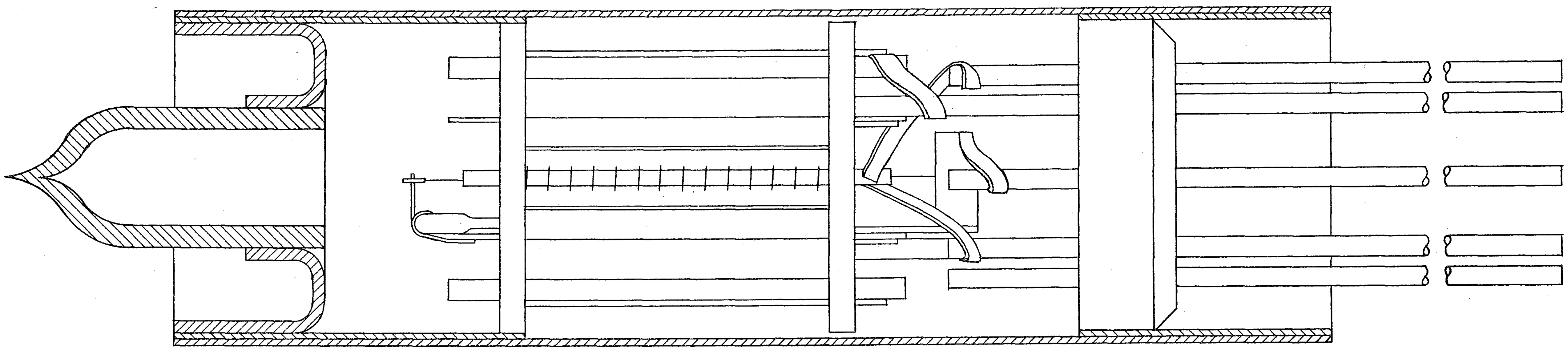
PART	BILL OF MATERIAL	REFERENCE DRAWING	2
1	SIDE ROD	A26075-1	2
3	FACE PLATE	A26076-1	2



A.- APERTURES TO BE ALIGNED WITHIN ±.0005.

REVISIONS
ERS 6322
1-10-66 0

"A" SIZE SPECIFICATION FORM NO. CM-48-TC 8-61



ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: .X ± .XX ± XXX ±
ANGLES: ± FRACTIONS: ±
MATERIAL:

CONTR NO.
DR
CHK
APPD
APPROVED
BY DIRECTION OF

RAYTHEON

RAYTHEON COMPANY
LEXINGTON, MASSACHUSETTS

TUBE ASSEMBLY
(OPENED FOR INSPECTION)

SIZE B | CODE IDENT NO. 49956
SCALE | SHEET

NEXT ASSY	USED ON
APPLICATION	

FORM NO. 10-0709 VELLUM 10-0710 GRID VELLUM 10-0711 FILM PRINTED IN U.S.A.

X-9

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

201572 SHEET ONE — REV. 1

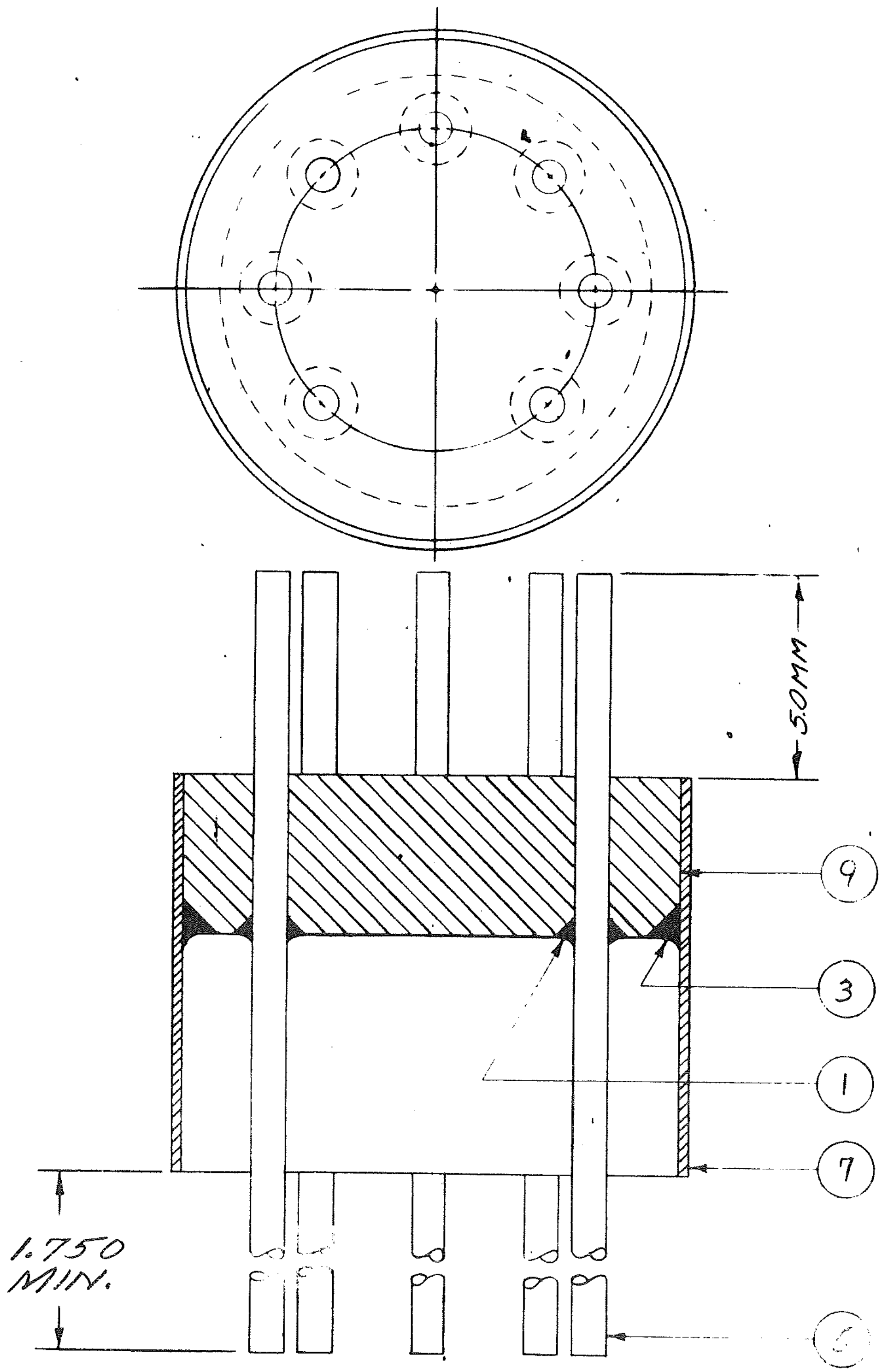
DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED

DIMENSIONS IN INCHES UNLESS NOTED
DO NOT SCALE PRINT

STEM ASSEMBLY
(UNFINISHED)

QUANTITIES REQUIRED PER GROUP

A	ITEM	BILL OF MATERIAL	REFERENCE DRAWING	GROUP 1
18.146	1	WIRE-BRAZING RING (LEADS)		
24	3	WIRE (BRAZING RING)		
30.115	5	WIRE-BULK (LEAD)	201102-603	7
31.2	7	TUBE-METAL (SEALING RING)	207989-58	1
31.3	9	INSULATOR - STEM (METALIZED & PLATED)	201573-2	1
30.118				



REVISIONS

POC64-5197. rjs 6·24·64.	0
POC66-5147 7-27-66	1

"A" SIZE SPECIFICA ORM NO. CH-48-TC 5-61

	RAYTHEON COMPANY **INDUSTRIAL COMPONENTS DIVISION**	201574 REV. 1

DIMENSIONS WITHOUT TOLERANCES ARE REFERENCE DIMENSIONS AND ARE NOT TO BE CHECKED

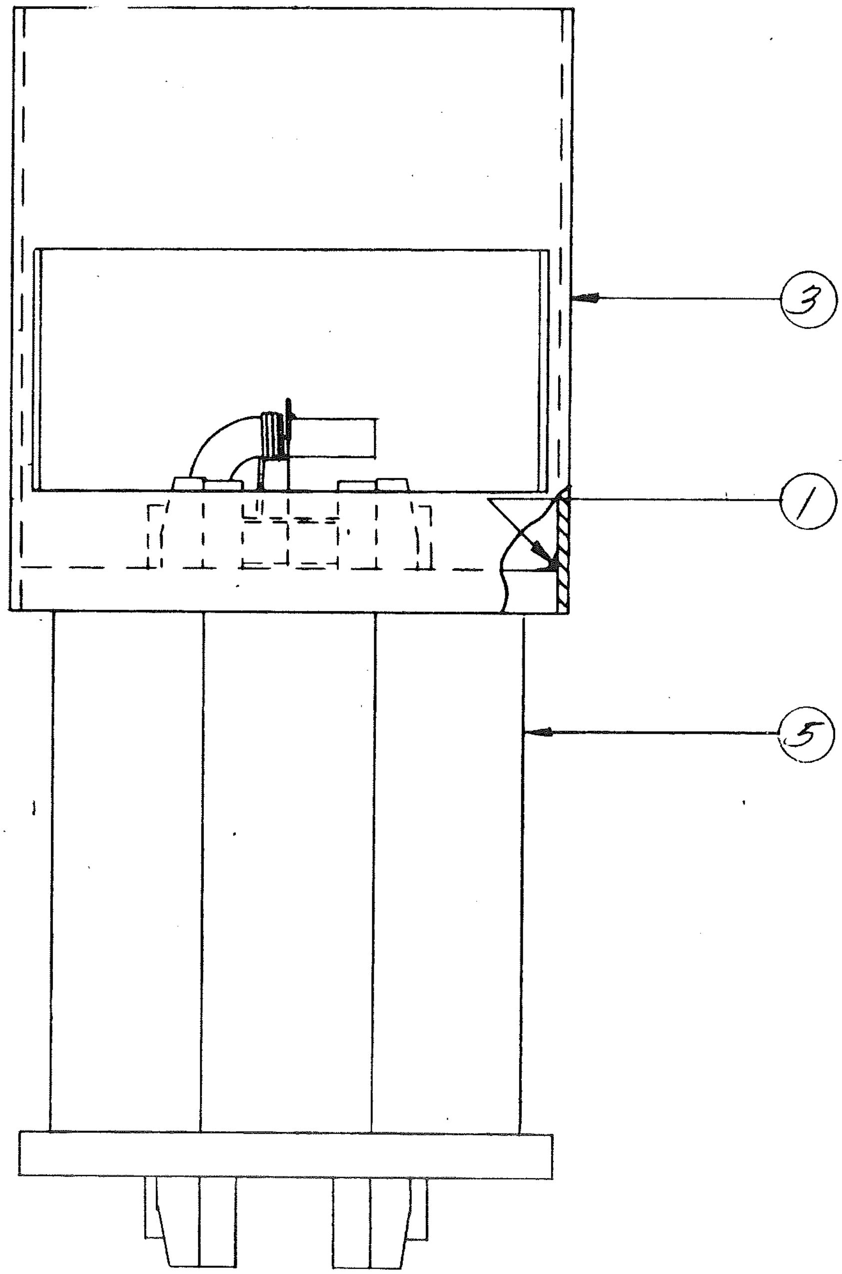
DIMENSIONS IN INCHES UNLESS NOTED
DO NOT SCALE PRINT

MOUNT ASSEMBLY
(WITH SEALING RING)

QUANTITIES REQUIRED PER GROUP

PART	BILL OF MATERIAL	REFERENCE DRAWING	GROUP 2
1	WIRE (BRAZING RING)	201190-36	1
3	TUBE-METAL (SEALING RING-REQP.)	26212-1	1
5	MOUNT ASSEMBLY	201575	1

18.146
30.115
31.5
38



91
291

REVISIONS

POC66-5147 7-28-66	1

"A" SIZE SPECIFICA FORM NO. CM-48-TC 8-61

RAYTHEON COMPANY
INDUSTRIAL COMPONENTS DIVISION

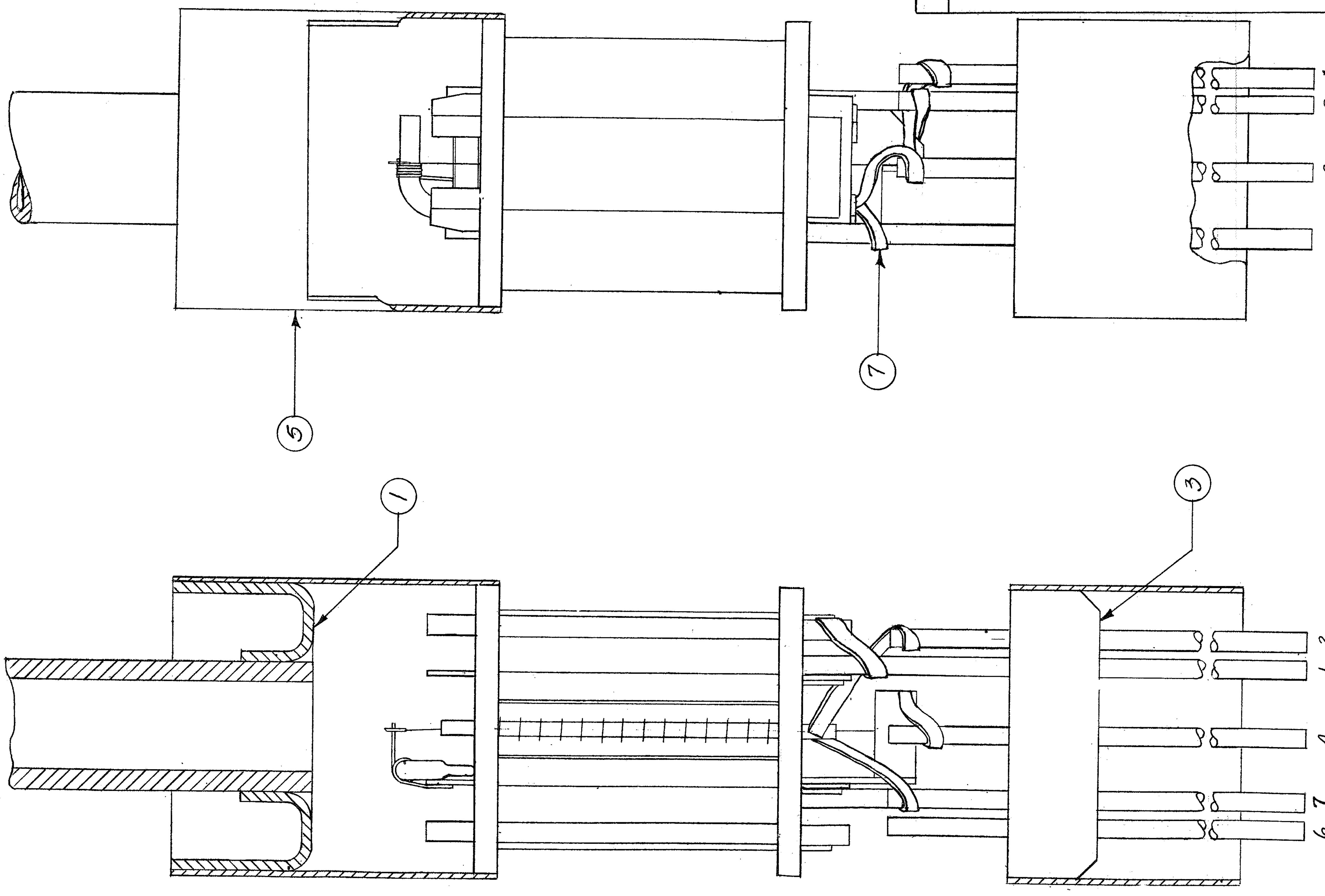
MOUNT ASSEMBLY
(WITH EXHAUST CAP & STEM)

201569 | 0

GROUP 2

ITEM	BILL OF MATERIAL		
1	CAP ASSEMBLY	201570-2	1
3	STEM ASSEMBLY (CUT)	201572-2	1
5	MOUNT ASSEMBLY (WITH SEALING RING)	201574-2	1
7	RIBBON-CUT (CONNECTOR)	208324-31	5

A
18.146
30.115
31.5
38



X-12

POC 64-5197.
AJ
6-30-64
0

APPENDIX XI

GLOSSARY OF SPECIAL TERMS

SEALING-IN — This process involves attaching the glass envelope with its tubulation to the tube button or leads in such a manner that the seal will be leak tight. It is then possible to evacuate the glass envelope through the tubulation.

FLUSHING GAS — This is an inert gas such as nitrogen or carbon dioxide which is circulated around the tube elements during the sealing-in process. The presence of the inert gas in the tube during this process prevents oxidation of the tube elements from the heat required to melt the glass to perform the sealing-in operation.

BAKE-OUT — Tubes undergoing exhaust are heated one or more times during the process to drive out water vapor and other absorbed gases from the tube component surfaces.

EXHAUST CYCLE — The exhaust cycle follows the sealing-in process and during this cycle the tube is evacuated, the metal elements are degassed, and the filament or cathode and heater are heated to drive off the coating binders.

TIP-OFF — Upon the completion of the exhaust cycle the tubulation is heated close to the top of the glass envelope to drive off gases in the glass. Additional heat is then applied to complete the seal-off of the finished tube.

ACTIVATION (AGING) & STABILIZATION

Activation is accomplished by heating the emitting surface to a suitable temperature to form a mono-molecular layer of barium on the surface of the filament or cathode. An electron current is then drawn which causes the evolution of gas from the parts of the tube that are being bombarded.

Stabilization is accomplished by operating the tube under regular operating conditions for a prolonged period of time.

HOT-SHOT — During the activation cycle the application of a filament voltage which is approximately four times the normal operating voltage results in heating currents which produce filament or cathode temperatures up to 1100^{o}C. This is known as a filament "Hot Shot" or "Flashing" and may be applied for a period of ten seconds up to two minutes. Raising the filament or cathode temperature to the above value assures complete conversion of the coating from carbonates to oxides.

DRI-FILM — The word "Dri-Film" is used to refer to a water repellent film which is placed or formed on the outside surface of a glass tube envelope. The most common films experimented with during the contract were produced from the chemical reaction between reactive chloro-silanes and the water in the glass surfaces.

FLASHLESS GETTER

This getter is a bulk getter (powder, wire, or sheet) which is not flashed but employed in its original shape, as opposed to the flash type wherein a metal or metals are vaporized and deposited as a film on the inside of the tube envelope.

T 1 1/2 x 2 (Rectangular)

This designation identifies the small rectangular glass envelopes used for small filamentary tubes. Multiplying the above values by 1/8" provides the nominal values of 3/16"x 1/4". Specifications call for maximum overall O. D. dimensions of 0. 230" x 0. 290".

T 2x3 (Rectangular)

Nominal dimensions 1/4" x 3/8". Specifications call for maximum overall O. D. dimensions of 0. 285" x 0. 385".

T 3 (Round) — Nominal O. D. is 3/8". Specifications call for a maximum overall O. D. dimension (including flat press) of 0. 400".

T 5 1/2 (Round) — Nominal O. D. is 11/16". Specifications call for a maximum overall O. D. dimension of 0. 750".

APPENDIX XII

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